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SUMMARY REPORT ON THE LONG-TERM WATER QUALITY OF THE SOUTH PLATTE RIVER BASIN. 1966-1972

ENVIRONMENTAL PROTECTION AGENCY

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16. ABSTRACT

An analysis of water quality data from twenty-one water quality surveillance stations located in the South Platte River Basin of Colorado was conducted. The data collected from 1968 through 1972 indicate significant deterioration of surface water quality in the Denver Metropolitan Area. Total and Fecal Coliform concentrations have increased by two to three orders of magnitude in recent years along with increased BOD_5 concentrations, and Dissolved Oxygen concentrations have sometimes dropped below acceptable limits (<5 mg/l). The analysis indicates a need to improve water quality with respect to these parameters in order to achieve proposed water quality objectives. A monitoring system is proposed to improve data reliability and provide information on previously undefined variables.

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Abstract

Analysis of water quality data collected from twenty-one water quality surveillance stations located in the South Platte River Basin of Colorado indicate significant deterioration of surface water quality in the metropolitan Denver Area. Data collected from 1968 through 1972 show an increase in bacteriological contaminants in the recent years. Total coliform bacteria concentrations increase three orders of magnitude to $5x10^5$ organisms per 100 ml through the metropolitan area and this degradation continues downstream to Nebraska. In a similar fashion, fecal coliform bacteria concentrations increase about two orders of magnitude to 5000 organisms per 100 ml. Concentrations of dissolved oxygen, as measured, show a complex variation with time but the low concentrations (<5mg/l) are limited to the immediate metropolitan area and occur approximately twenty percent of the time (in 1972). BOD_5 concentrations have increased significantly in the latter part of 1972 and early 1973 in the stream reach immediately downstream from the Denver Metropolitan area, and are thought to relate primarily to increased organic waste discharges from the Denver Metro Sewage Treatment Plant. Any pH problems appear related to alkaline runoff since low pH's have not been observed. Water temperatures are generally within biological bounds, but data are lacking for tributaries and discharge mixing zones. Nutrient data suggest that concentrations are high enough to be of concern insofar as algal growth potential is concerned.

Comparison of the surface water quality data with objectives of improving the surface water quality shows a need to decrease coliform concentrations and increase dissolved oxygen concentrations in the South Platte River. The analysis also points out certain weaknesses in the present frequency of sample collection and analysis from the surveillance network.

A surface water quality monitoring system comprised of thirteen long-term stations is proposed. Also proposed is a shorter-term sampling program to define such variables as mixing zones, ground water recharge, flow rates, effect of barriers, and the impact on quality of minor tributaries and "storm" drains.

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INTRODUCTION AND PURPOSE

In the Region VIII Accomplishment Plan for the South Platte River - Denver Metro area, the commitment was made to the preparation of a comprehensive report describing the quality of waters in the South Platte River Basin in Colorado.[1/] This report draws upon an extensive data base in an attempt to provide a reasonably quantitative description of water quality in the main stem of the South Platte and its major tributaries (Bear Creek, Cherry Creek, Clear Creek, St. Vrain Creek, the Big Thompson River, and the Cache La Poudre River). The description of water quality is termed "reasonably quantitative" since the methods of calculating averages and means were not statistically strict. The primary analysis effort has been directed toward those parameters that are controlled by present and proposed water quality standards; namely, coliform bacteria, dissolved oxygen, pH, and temperature. Also included in the analysis were BOD concentrations and nutrients in the form of phosphate and nitrogen compounds.

The specific objectives of this report are:

1. To place the water quality data pertinent to the Regional Accomplishment Plan for the South Platte River Basin in one summary report.
2. To evaluate the existing data and to identify any stream areas for which inadequate data were found.
3. To recommend a sampling program that will facilitate the measurement of subsequent changes in water quality in the South Platte River Basin.

The "Regional Accomplishment Plan for the South Platte River Basin" proposed, as an objective under "Water Quality," the improvement of the quality of the South Platte River to permit contact recreational use (a classification presently termed "B_3") from the headwaters of the South Platte to somewhere in the vicinity of Englewood, Colorado (near River Kilometer (RK) 524). The Accomplishment Plan also proposed the objective of improving the waters from Exposition Avenue (RK 518.4) to the Colorado-Nebraska State Line. The exact locations of changes in the proposed standards ("objective" classifications) have not been specified. As will be explained later, some arbitrary decisions as to classification changes were made to facilitate the data analysis. The EPA objectives are stated, in the Plan, as follows:

1/ "Accomplishment Plan Region VIII South Platte River Basin Denver Area," Environmental Protection Agency, Rocky Mountain Prairie Region, January 1972.

SOUTH PLATTE RIVER BASIN

BROAD OBJECTIVES

2.1 Water Quality

To improve quality of the South Platte River to permit beneficial uses not now provided as follows:

a. Water quality upstream from Denver will be improved to permit recreation, including swimming, and drinking water supply through reduction of fecal coliform levels. Existing fecal coliform levels will be reduced by approximately 50% to the compliance level of 100 per 100 ML by December 31, 1973.

b. Quality of Water in the Denver area and downstream to the Colorado-Nebraska State line will be improved to permit drinking water supply and warm water fisheries through reduction of fecal coliform and through an increase in the dissolved oxygen level. Existing fecal coliform levels in excess of 10,000 per 100 ML will be reduced by 30% below Greeley, Colorado by December 31, 1972. Fecal coliform levels in the entire reach in and below Denver will be brought to the compliance level of 1,000 per 100 ML by December 31, 1976. Dissolved oxygen compliance level of 5.0 milligrams per liter will be met in this reach by December 31, 1976 through a reduction of 40,000 pounds of biochemical oxygen demand per day by the end of 1976.

Thus the analysis incorporated in this report is focused on fecal coliform bacteria concentrations, dissolved oxygen concentrations, and biochemical oxygen demand data since these parameters are utilized to express objectives in the Accomplishment Plan.

CLASSIFICATIONS OF WATERS OF THE SOUTH PLATTE RIVER BASIN IN COLORADO

CURRENT AND "OBJECTIVE"

Current stream classifications in Colorado protect the South Platte River from its source to Exposition avenue (RK 518.4) for municipal water supplies, cold-water fishery, industrial, and irrigation uses. From Exposition Avenue downstream to York Street (RK 518.4 to RK 504.4) the classification provides for a warm-water fishery plus industrial and irrigation uses. From York Street to the Colorado-Nebraska State Line (RK 504.4 to RK 134.7), the classification provides for industrial and irrigation uses. The quantitative limits coinciding with these classifications are presented in Table 1.

Table 1 also presents the "objective classifications" and their quantitative limits as they have been derived and applied to the South Platte River. Table 2 presents these classifications for the major tributaries to the South Platte River. The "objective classification" are those standards that are proposed for the River i.e., classification objectives. The points of "objective" classification change were selected to coincide with present stream locations of classification change. These "objective classifications" and the reach designations have evolved from the "Accomplishment Plan" as this Plan is affected by the Federal Water Pollution Control Act Amendments of 1972.

Both the current and "objective" classifications have been used as a basis for comparisons in the ensuing presentation of water quality data. It must be noted that the selection of "objective" classifications, though discussed with others, was primarily an arbitrary process conducted by the authors and should be considered only as such and, therefore, subject to further discussion and change.

WATER QUALITY DATA FOR SOUTH PLATTE RIVER BASIN

Introduction - Stations Examined

A large number of locations have been occupied within the South Platte River Basin for the purpose of water quality determinations. A total of twenty-one long-term water quality monitoring stations were selected as the basis for this report. These stations are described in Table 3 and their location shown in Figure 1 (in rear pocket). Table 3 also lists the water quality parameters measured at each station. This report treats only those water quality parameters considered critical in terms of the goals for improvement of the South Platte River.

The following sections present the existing water quality data in a parameter-by-parameter fashion, and, within the framework of each parameter, in an upstream to downstream order.

Method of Analysis of Data

The data in existance for the South Platte River Basin have been analyzed in a semi-quantitative fashion since the use of thoroughly quantitative analytical methods would require resources that are not presently available. It was observed in the early stages of the data analysis that simple concentration averages over periods of record did not always present a true picture of current or even historical water quality at a particular sampling location. Therefore, a more intensive investigation of all available individual data points were undertaken to check the occurrence of seasonal or yearly variations. This investigation utilized the STORET data system to obtain time-versus-concentration plots of selected parameters at the desired sampling locations (see Appendix A). Note that an upper bound has been placed upon the data-plots according to the parameter plotted. As an example, an upper bound of $1X10^5$ total coliform per 100 ml was set.

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TABLE 2

Quantitative Water Quality Standards for Major Tributaries
to the South Platte River in Colorado

Stream	Present Classifications 4/ Letter Designation	ln total coli/100ml	ln fecal coli/100ml	DO (mg/l)	pH (su)	TDS (mg/l)	Temperature (°F)
Bear Creek to Morrison	A_1, B_2, D_1	no std.	≤ 1000/ 2000 (10)	≥ 6	6.5 8.5	≤ 500	≤ 70
Bear Creek Morrison to S. Platte	B_2, D_1	no std.	≤ 1000/ 2000 (10)	≥ 5	6.5 8.5	TWMM 3/	≤ 90
Cherry Creek Reservoir	B_2, D_1	≤ 1000 m.a. 2/	≤ 100	≥ 5	6.5	no std.	≤ 90
Cherry Creek Res. to S. Platte	none	no std.	no std.	no std.	no std.	no std.	no std.
Clear Creek-Source to Farmers Highline Canal	A_1, B_2, C, D_1	no std.	≤ 1000/ 2000 (10)	≥ 6	6.5 8.5	500	≤ 70
Clear Creek-Farmers Highline Canal to S. Platte	A_1, C, D_1	no std.	≤ 1000/ 2000 (10)	≥ 4	6.0 9.0	500	≤ 90
St. Vrain Creek Lyons to S. Platte	B_2, D_1	no std.	no std.	≥ 3	5.0 9.0	TWMM	≤ 90
Boulder Creek Boulder Canyon to S. Platte	B_2, C, D_1	no std.	≤ 1000/ 2000 (10)	≥ 5	6.5 8.5	TWMM	≤ 90
Big Thompson River Loveland WTP to S. Platte	C, D_1	no std.	no std.	≥ 3	5.0 9.0	TWMM	≤ 90
Cache La Poudre R. Greeley WTP Diversion to 2nd Ave. Greeley	B_2, C, D_1	no std.	≤ 1000/ 2000 (10)	≥ 5	6.5 8.5	TWMM	≤ 90
Cache La Poudre R. 2nd Ave. Greeley to S. Platte	C, D_1	no std.	no std.	≥ 3	5.0 9.0	TWMM	≤ 90

1/ Log mean (lm)

2/ Monthly average for 5 consecutive samples (m.a.)

3/ Time Weighted Monthly Mean (TWMM)

4/ Present classifications are based upon Colorado Water Quality Standards dated September 1, 1971

TABLE 3

Water Quality Monitoring Stations - South Platte River Basin
(Utilized in this Report)

Location	River[1] Kilometers	River[1] Miles	Period of Record	Primary Parameters: Fecal Coliform	Total Coliform	Do	BOD	Temp	pH	T-PO_4	NO_3-N	NH_3N	Sampling Agency	Agency Station No.
South Platte River South Platte	564.5	350.8	11/68-10/72	X	X	X	X	X	X	X	X	X	Colo. St. Health Dep.	000025
South Platte River Highway 470	539.0	334.9	12/68-9/72	X	X	X	X	X	X	X	X	X	Colo. St. Health Dep.	000024
South Platte River Bowles Avenue	530.7	329.8	12/67-12/72	X	X	X	X	X	X	-	-	-	Denver Co. Health Dep.	1513
Bear Creek Jeff-Arap. County Line	525.3/6.8	326.4/4.2	1/68-10/72	X	X	X	X	X	X	X	X	X	Colo. St. Health Dep.	000036
South Platte River Dartmouth Avenue	524.1	325.7	10/66-12/72	X	X	X	X	X	X	-	-	-	Denver Co. Health Dep.	1091
	523.0	325.	Standards change from A, B_1, C, D_1 to B_1, C, D_1											
	518.4	322.1	Standards change from B_1, C, D_1 to B_2, C, D_1											
South Platte River Alameda Avenue	517.4	321.5	10/66-12/72	X	X	X	X	X	X	-	-	-	Denver Co. Health Dep.	0699
Cherry Creek at Mouth	511.3/0.2	317.7/0.1	10/66-12/72	X	X	X	X	X	X	-	-	-	Denver Co. Health Dep.	0346
South Platte River 19th Street	510.8	317.3	10/66-12/72	X	X	X	X	X	X	-	-	-	Denver Co. Health Dep.	0305
South Platte River Franklin Street	506.3	314.6	10/66-12/72	X	X	X	X	X	X	-	-	-	Denver Co. Health Dep.	0001
	504.4	313.4	Standards change from B_2, C, D_1 to C, D_1											
Clear Creek upstream from Golden	500.7/28.8	311.1/17.9	5/68-10/72	X	X	X	X	X	X	X	X	X	Colo. St. Health Dep.	000035
Clear Creek near Mouth	500.7/0.8	311.1/0.3	1/68-11/72	X	X	X	X	X	X	X	X	X	Colo. St. Health Dep.	000034

1) Measured from mouth of South Platte River at Colorado-Nebraska State Line

TABLE 3

Water Quality Monitoring Stations - South Platte River Basin
(Utilized in this Report)

Location	River[1] Kilometers	River[1] Miles	Period of Record	Primary Parameters									Sampling Agency	Agency Station No.
				Fecal Coliform	Total Coliform	Do	BOD	Temp	pH	T-PO_4	NO_3-N	NH_3N		
South Platte River at Henderson	485.5	301.7	1/68-11/72	X	X	X	X	X	X	X	X	X	Colo. St. Health Dep.	000023
St. Vrain Creek Downstream from Longmont	434.5/27.7	270.0/ 17.2	4/69-10/72	X	X	X	X	X	X	X	X	X	"	000031
St. Vrain Creek Near Mouth	434.5/2.1	270.0/ 1.3	1/68-11/72	X	X	X	X	X	X	X	X	X	"	000029
Boulder Creek Boulder-Weld County Line	434.5/28.0 11.3	270.0/ 17.4/7.0	4/68-10/72	X	X	X	X	X	X	X	/	X	"	000033
Big Thompson River Near Mouth	419.1/1.4	260.4/ 0.9	1/68-11/72	X	X	X	X	X	X	X	X	X	"	000028
Cache La Poudre upstream from Ft. Collins	400.7/90.6	249.0/ 56.3	1/68-10/72	X	X	X	X	X	X	X	X	X	"	000026
Cach La Poudre River Near Greeley	400.7/4.7	249.0/ 2.9	1/68-11/72	X	X	X	X	X	X	X	X	X	"	000027
South Platte River Near Kersey	396.7	246.5	1/68-11/72	X	X	X	X	X	X	X	X	X	"	000022
South Platte River At Balzac	280.0	174.0	1/68-11/72	X	X	X	X	X	X	X	X	X	"	000021
South Platte River Near Julesburg	140.0	87.0	1/68-8/72	X	X	X	X	X	X	X	X	X	"	000020

1) Measured from Mouth of South Platte River at Colorado-Nebraska State Line

Thus, high values such as two of about 1.7 and $1.3X10^6$ total coliform per 100 ml measured in 1966 and 1967 at the 19th Street bridge (RK 510.6) were not plotted. Similarly, high concentrations of coliform bacteria measured in 1966 for South Platte River samples at the Franklin Street Station are not shown since all values measured in 1966 exceeded $1X10^5$ coliform per 100 ml. If no upper bound had been set and these high concentrations had been included in the computer-plots, then the resulting line graph would have been skewed upward so far that the lower data points representing much lower concentrations of coliforms (such as those near the concentration limit of 1000 total coliforms per 100 ml) would have been compressed and barely distinguishable on the bottom of the graph. The upper bound was also used to eliminate obviously incorrect (too high) values such as a D.O. measurement of 50 mg/l on 4 Jul 70 at the 19th Street Bridge Station.

No attempt was made to provide accurate geometric or log means of all the historic data for total and fecal coliforms. Standards for these parameters are based upon the collection of more than a single sample once each month or two week period, and the majority of the data presented herein was collected only monthly or biweekly. As a result, the calculation of daily or monthly means using the historic data is statistically inaccurate and the historic data are inadequate for specific comparison with the standards.

In contrast, the values plotted as median values on the summary plots (Figures 3, 5, 7, 9, 11, and 12) are either arithmetic means or approximate median values for the historic data for all parameters. The use of mean or median values was determined by the degree of variability of the individual data points. Means were used for normal distributions of data and medians were used for assymetrical distributions of data. The range of values included within the "standard deviation" - type limits used in the summary graphs takes into account all but the most extreme values reported for that period of record which appears to best describe the "current" quality of the South Platte River. Thus, if an improvement over time is indicated, the summary graph shows only the range of concentrations for the recent past as opposed to the longer historic period of record.

Certain of the data presentation graphs include the results of water quality measurements made by the EPA National Field Investigations Center-Denver during 1971.[2/] In some cases these 1971 "special survey" data were collected at the same locations as are the long-term data. In cases of differing locations, the river mileage of the 1971 "special survey" location is denoted.

It should also be noted that no attempt was made to resolve differences between the "Most Probable Number" (MPN) and "Membrane Filter" (MF) methods of coliform determination. All coliform data were considered equivalent in the summary graphs. No correlation between the results of the two methods has been determined.

2/ "Report on Effects of Waste Discharges on Water Quality of the South Platte River-Denver Metropoliton Area" & "Report on Effects of Waste Discharges on Water Quality of the Cache La Poudre & S. Platte Rivers-Greeley Area." Both reports by the EPA National Field Investigations Center-Denver & the EPA Region VIII Office, Denver, Colorado, June, 1972.

The graphical presentation was selected to facilitate reading and comprehension.

In brief summary, the Figures should provide a reference for future measurements. If, for example, BOD_5 data collected in 1973 show a mean concentration lower than that portrayed in Figure 9, we should be able to conclude that the quality of the South Platte is, in fact, improved. Similarly, if all the BOD_5 measurements for 1973 fall well below the upper bound of the range shown in Figure 9, the water quality of the South Platte should be improving. Of course exceptions to such general conclusions can be developed.

If such comparisons are attempted in the future, one must consider that infrequent (weekly, monthly) measurements of water quality at a long-term monitoring station do not necessarily reflect short term, yet lethal, impacts on the surface water system. Such short term increases in pollutants may, in fact, prevent attainment of desired stream classifications. With the exception of some recent measurements made in the urban area of the South Platte River (these data are not included here), the historic data have been derived from an infrequent measurement schedule.

Coliform Bacteria Measurements

Total Coliform Bacteria

Sampling locations utilized for examination of Total Coliform Bacteria are shown in Figure 2. An analysis of samples collected at these locations reveals that the South Platte River contains relatively high concentrations (in excess of $1X10^6$ organisms per 100 ml) of total coliform bacteria as it passes through the metropolitan area (Figure 3). The river is considered to have undergone significant deterioration by the time it passes Bowles Avenue (RK 530.7) and to reach a peak in coliform concentration at Franklin Street (RK 505.3). The deterioration is evidenced by an increase in coliform concentrations from about 100 to about $5X10^5$ organisms per 100 ml. The River never fully recovers to upstream concentrations while flowing on through Colorado. Further, significant variations (100-fold) in concentrations have been measured at all locations downstream of, and including, Franklin Street (RK 505.3). No total coliform standards presently apply to the South Platte River. Assuming that the objective standard would be 1000 organsims per 100 ml upstream of Exposition Avenue (RK 518.4 to the headwaters) and 10,000 organisms per 100 ml downstream of Exposition Avenue (RK 518.4 to RK 134.7), a high percentage of potential violations of standards was suggested by the data review. Data shown in Table 4 summarize the possible violations of total coliform bacteria limits in terms of the recent (1972) data, and the last 3 years of data (1970-1972). This summary suggests a recent (1972) deterioration of the South Platte River in terms of total coliform bacteria carried through the metropolitan area (RK 517.4 to RK 505.3). Conversely, some improvement in quality downstream of the metropolitan area was suggested by the decrease in total coliform bacteria carried in the South Platte River from its junction with Clear Creek (RK 500.7) downstream to the State Line (RK 134.7).

The results of examination of the time-plots (Appendix A-1) for each station suggest that the trend since 1966 has been toward a ten-fold, or order

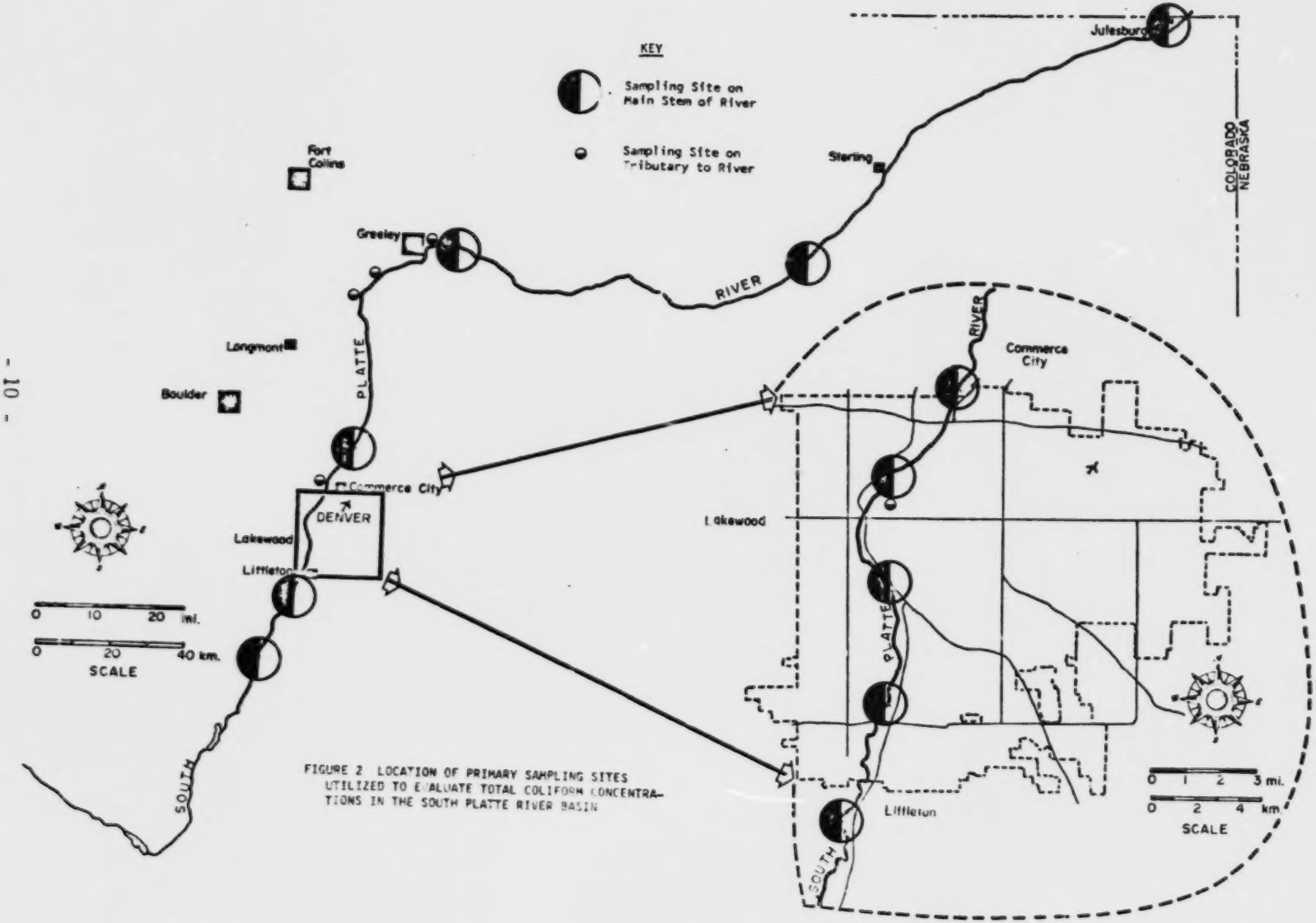


FIGURE 2 LOCATION OF PRIMARY SAMPLING SITES UTILIZED TO EVALUATE TOTAL COLIFORM CONCENTRATIONS IN THE SOUTH PLATTE RIVER BASIN

FIGURE 3

Current Concentration of Total Coliform Bacteria (Median and Range) For South Platte River Basin In Colorado
Based On Selected Data

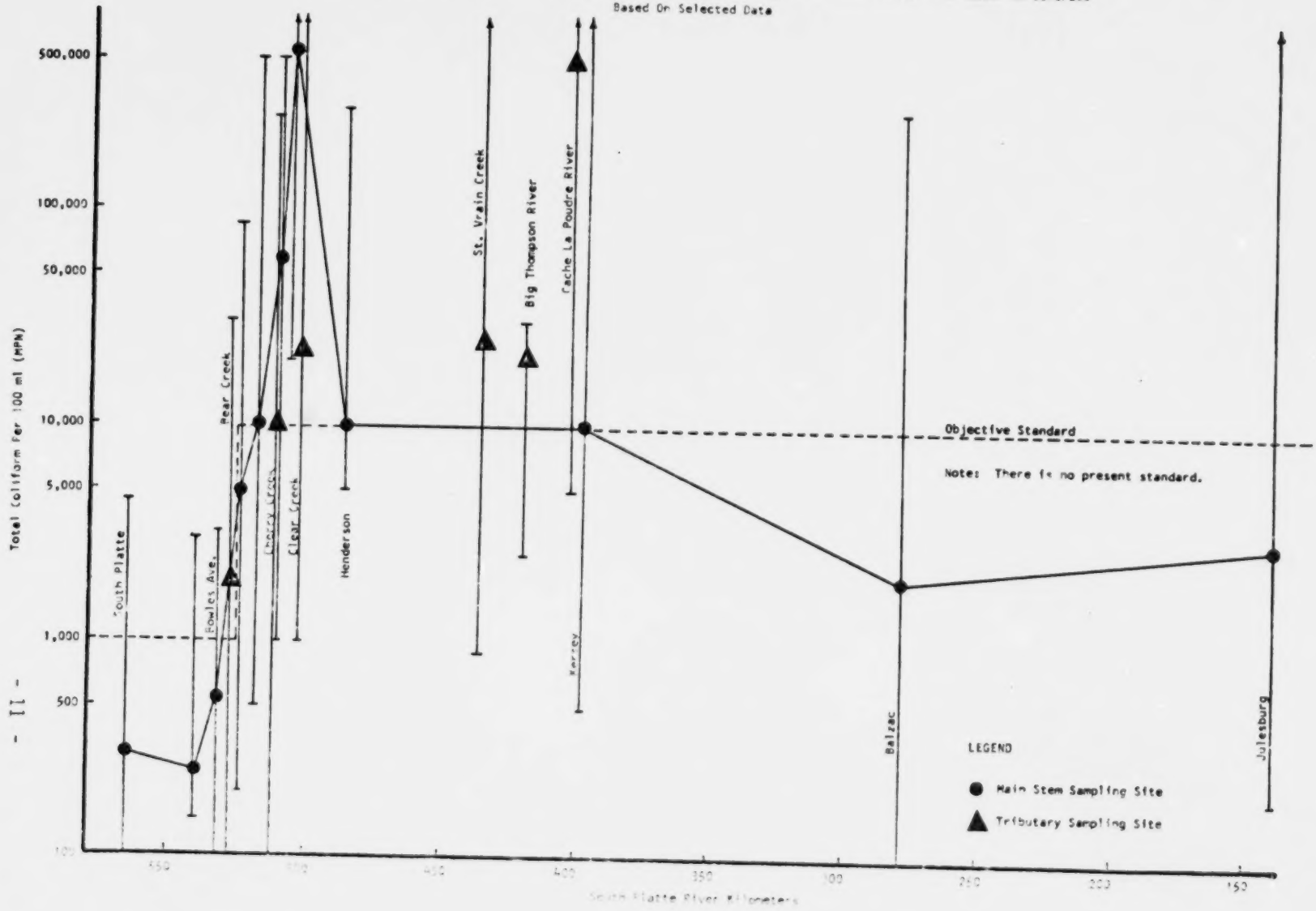


TABLE 4

Total Coliform Bacteria - Analysis of Extremes

Station location	Objective Standard (log mean/100 ml)	Percentage of single measurements exceeding stated objective standard 1970-1972	1972
South Platte	1000/2000	20	0
I-470	1000/2000	14	0
Bowles	1000/2000	9	5
Bear Creek	10000	14	17
Dartmouth	10000	16	14
Alameda	10000	15	23
Cherry Creek	10000	36	36
19th Street	10000	33	38
Franklin	10000	56	95
Clear Creek	10000	72	40
Henderson	10000	74	50
St. Vrain Creek	10000	71	71
Big Thompson River	10000	75	71
Cache La Poudre River	10000	81	57
Kersey	10000	56	43
Balzac	10000	29	0
Julesburg	10000	43	0

of magnitude, decrease in total coliform bacteria concentrations in the South Platte River. The derivation of this trend is strongly based on the very high coliform bacteria concentrations measured in 1966 by the City and County of Denver Health Department. Review of the data without these 1966 values would not be as optimistic toward long-term improvement since the concentrations appear to have remained about the same since 1968 and have increased with time through the downstream area as discussed previously in connection with Table 4.

Data collected in the latter half of 1971 by the EPA National Field Investigations Center-Denver[2] and represented in the graphs in Appendix A-1 by solid vertical lines show higher concentrations by an average factor of about 5, at certain locations on the South Platte River (Bowles Avenue, Kersey, Julesburg) and on certain tributaries than are suggested by the long-term data. On the other hand, field investigations by the Regional EPA office[3] during mid-1972 on the upper South Platte River revealed approximately the same mean total coliform value (425 per 100 ml, average of 17 measurements) at Bowles Avenue as is shown by the long-term data. The factors influencing such comparisons are too numerous to describe here, but basically they relate to the size of the sample (number of samples and period of time over which the sampling occurred).

Fecal Coliform Bacteria

Sampling locations utilized for analysis of concentrations of fecal coliform bacteria are shown in Figure 4. Starting at Bowles Avenue (RK 530.7) and progressing downstream through the Denver metropolitan area, the South Platte River undergoes significant deterioration in terms of an increase in the fecal coliform concentrations (Figure 5). Upstream concentrations on the order of "<100" organisms per 100 ml increase to about 5000 organisms per 100 ml at Franklin Street (RK 505.3). With the additional contribution of fecal coliforms from the Big Thompson and Cache La Poudre watersheds, the River never recovers while flowing through Colorado. In a fashion similar to that for total coliform, the concentration of fecal coliform bacteria peaks at Franklin Street (RK 505.3) to concentrations as high as 150,000 organisms per 100 ml.

Fecal coliform standards presently exist for the South Platte River (Table 1) from the headwaters to the York Street bridge (RK 504.4). The standard reads as follows:

> "Bacteria: Wastes or substances from controllable sources shall not be discharged into these waters in amounts which will cause the number of organisms of the fecal coliform group, as determined by either multiple tube fermentation or membrane filter techniques, to exceed a log mean of 1000 per 100 ml or exceed 2000 per ml in more than 10% of the samples collected in any 30-day period."

3/ "Bacteriological Investigations of the Upper South Platte River Basin, May, July, and September, 1972," Rpt #S&A-TSB-6, Technical Support Branch, Surveillance & Analysis Division, Environmental Protection Agency, Region VIII, Denver, Colorado, December, 1972.

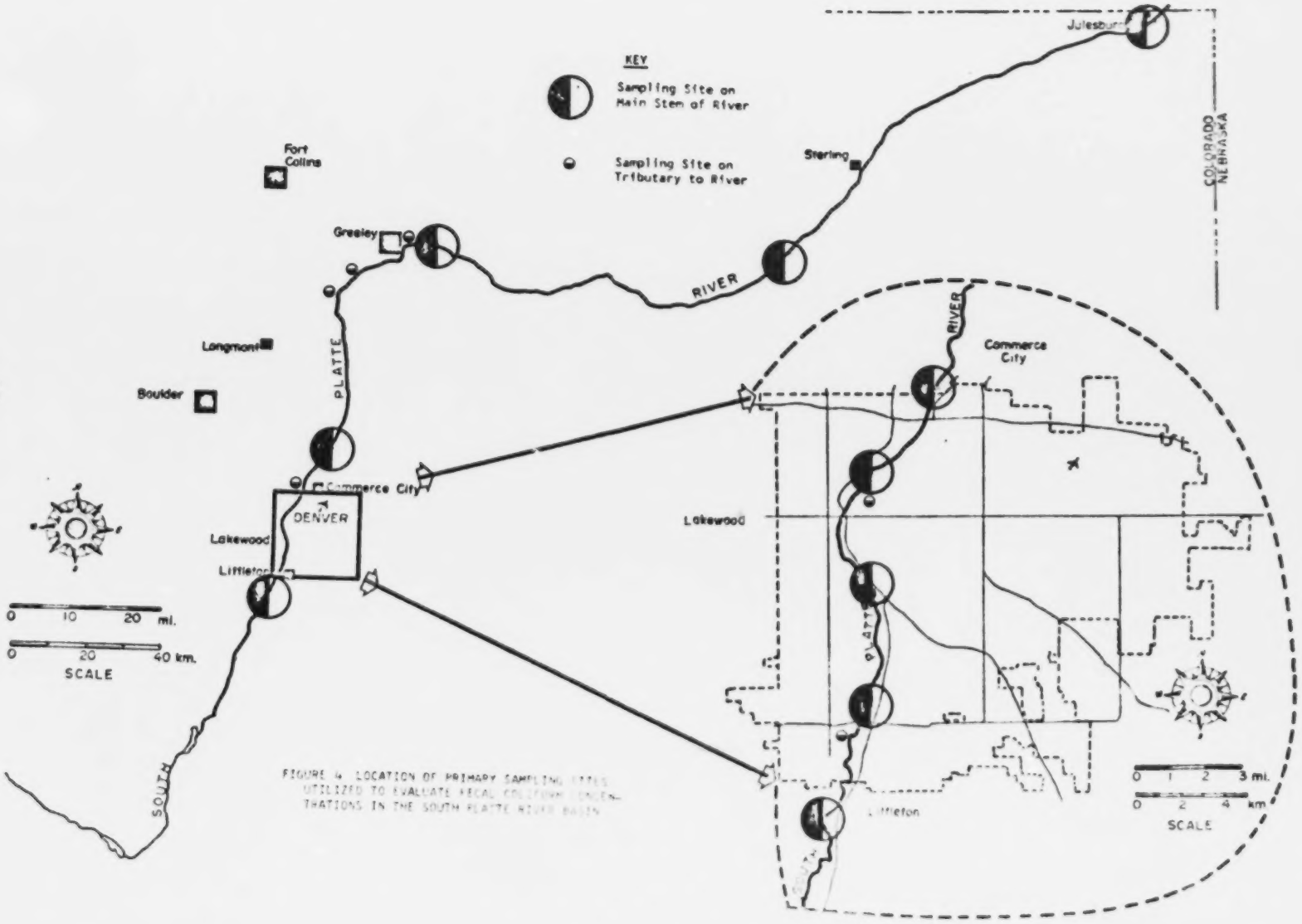
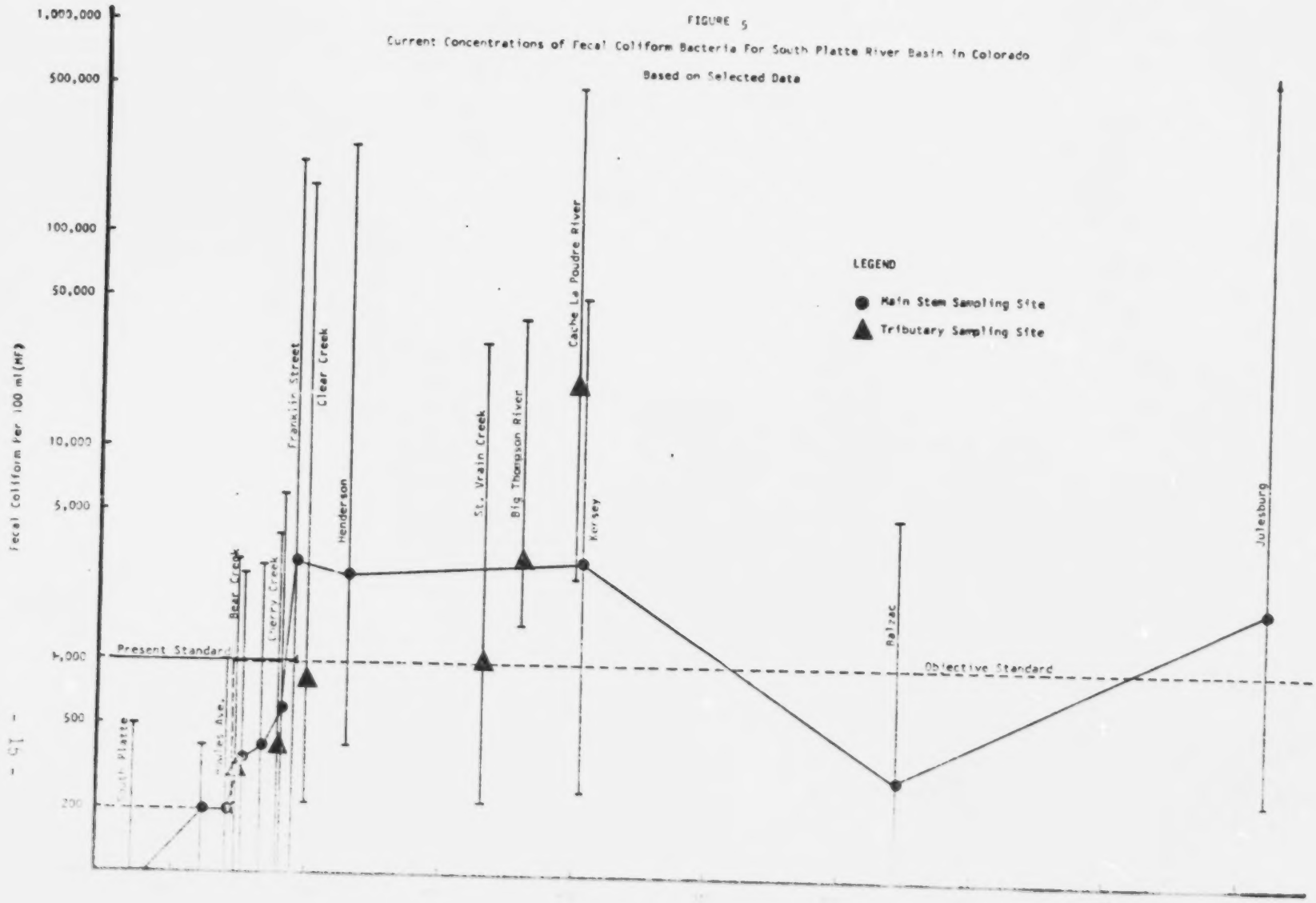


FIGURE 4. LOCATION OF PRIMARY SAMPLING SITES UTILIZED TO EVALUATE FECAL COLIFORM CONCENTRATIONS IN THE SOUTH PLATTE RIVER BASIN

FIGURE 5

Current Concentrations of Fecal Coliform Bacteria For South Platte River Basin in Colorado

Based on Selected Data



As discussed in an earlier section, the long-term data are grab samples collected at a relatively low frequency and cannot, therefore, generally be used to determine with certainty whether the maximum of 2000 fecal coliform per 100 ml has been exceeded over sufficiently long enough period to stand as a violation. This data can only be used as a general indication of the presence or absence of violations.

Based on such a use of the long-term data, it appears that the present water quality standards are exceeded at one South Platte main stem location i.e., Franklin Street (RK 505.3). If the present standard were extended downstream (as proposed by the objective standard), three additional locations would have excessively high fecal coliform concentrations-Henderson (RK 485.5), Kersey (RK 396.7) and Julesburg (RK 140.0).

The "objective" standards have been considered to be log or geometric means of 200 fecal coliforms per 100 ml from the source to Exposition Avenue (RK 518.4) and 1000 fecal coliform per 100 ml from Exposition Avenue to the State Line (RK 518.4 to RK 134.7)[4/]. Such standards are to be judged against the measurement of not less than five water samples collected in a 24-hour period. Maximums of 400/100 ml and 2000/100 ml for 10% of samples during a 30-day period are also proposed. Complicating the analysis is the problem that the 200/100 ml limit may be reduced to 100/100 ml in Colorado.

Indications are that fecal coliform concentrations will have to be decreased throughout the South Platte Basin to meet the "objective" standards. Estimated median values at I-470 and Bowles Avenue on the South Platte River (RK 539 and RK 530.7, respectively) are equal to the 200/100 ml standard. Estimated mean values at Franklin Street, Henderson, Kersey, and Julesburg on the South Platte River are high by a factor of 3 in comparison with the "objective" standards. Excursions of fecal coliform concentrations over the objective standards are sufficiently frequent at most stations to suggest that reductions in the concentrations of fecal coliform bacteria must be accomplished throughout the river system. Table 5 summarizes the frequency of occurrence of fecal coliform concentrations which exceeded the present standards or which would exceed the objective standards. Table 5 portrays a probable long-term (since 1970) improvement in the quality of the South Platte River in the area downstream of Denver (Kersey, Balzac, Julesburg) by virtue of the observed decrease in percentage of potential violations in that part of the downstream reach. The quality of the downstream tributaries appears to have neither improved nor worsened with respect to fecal coliform concentrations since 1970. However, it appears that the quality has decreased in the metropolitan area over the same period. In fact, the data collected at the Franklin Street location suggest serious deterioration in quality since 1970 (measured in terms of fecal coliform bacteria) since mean concentrations at this station have increased from 500 to 2000 to 5700 (organisms per 100 ml) from 1970 to 1972. In addition, there have been sporadic occurrences of very high ($\sim 2 \times 10^5$

4/ A more restrictive fecal coliform limit of 100/100 ml may be appropriate for the "primary contact" waters in the upstream reach.

TABLE 5

Fecal Coliform Data - Analysis of Extremes

Station location	Objective Standard (log mean/100 ml)	Percentage of single measurements exceeding stated objective standard 1970-1972	1972
South Platte	200	5	0
I-470	200	32	33
Bowles	200	13	0
Bear Creek	1000	19	0
Dartmouth	1000	16	10
Alameda	1000	13	23
Cherry Creek	1000	14	9
19th Street	1000	23	33
Franklin	1000	53	77
Clear Creek	1000	44	0
Henderson	1000	83	100
St. Vrain Creek	1000	71	71
Big Thompson River	1000	90	86
Cache La Poudre River	1000	95	100
Kersey	1000	68	43
Balzac	1000	33	20
Julesburg	1000	52	40

counts/100 ml) fecal coliform bacteria concentrations at a few sampling locations (Franklin Street and Henderson are the most notable locations). These values are not accurately reflected in the graph on page 78 in Appendix A-2 because nearly 70% of the reported values (for 1972) exceeded the set upper limit of the graph of 10^4 fecal coliforms per 100 ml and could not be depicted.

Dissolved Oxygen Measurements

Sampling locations utilized for analysis of Dissolved Oxygen are shown in Figure 6. Review of the long-term trends in concentrations of dissolved oxygen (DO) in the South Platte River Basin has proven to be a challenge. As may be construed from the station-by-station plots of DO measurements (Appendix A-3) an irregularly cyclic variation has been identified for all metropolitan sampling locations. The cyclic variations cannot be related either to the time of year or to mean annual flows. The variations in DO concentrations from 1967 through 1972 appear somewhat similar to a cross-section view of a saucer ( ) with major rises on either side (1967 and 1972) minor increases toward the middle (1969 and 1970). Unfortunately for the quality of the River, relatively low values of DO (on the order of 4 mg/l, see Figure 17) were measured during 1972 and a possible trend toward improvement of water quality (in terms of increased dissolved oxygen) was interrupted.

The DO content of the South Platte River decreases to an average of about 6 mg/l through the metropolitan area (see Figure 7) and then generally increases to about 8 mg/l downstream of the Henderson sampling station (RK 485.5). Present stream standards are set at 6 mg/l from the headwaters to Exposition Avenue (RK 518.4), 5 mg/l from Exposition Avenue to York Street (RK 518.4 to RK 504.4), and 3 mg/l downstream of York Street to the State Line. Some problems exist in meeting the current standards since approximately 20 percent of DO measurements made in 1972 at locations upstream of York Street, but within the metro area, were below the standards concentration of 5 mg/l. Especially indicative of problems were the results of DO measurements at Bowles Avenue (RK 530.7) where the estimated median value for the period of record (1967-1972) is just equal to the present standard or limit value of 6 mg/l.

Implementation of the objective standards would increase the present limit concentration of 3 mg/l, which applies downstream of York Street, to 5 mg/l (with occasional excursions to 4 mg/l acceptable) but would not change the upstream limits (see Figure 7). Table 6 summarizes the number of potential violations of the objective standards based on analysis of the 1970 thru 1972 data. As with other parameters previously discussed, an improvement in the dissolved oxygen content of the South Platte River throughout the metropolitan area must be achieved in order to meet the objective standards.

The results of the short-term surveys conducted during the second half of 1971 were generally in agreement with the long-term data with the exception of the Henderson location where short-term data showed a violation of present standards (2.4 mg/l measured in 1971) while the long-term data have not been lower than about 3.4 mg/l since 1968 (see page 85 in Appendix A-3).

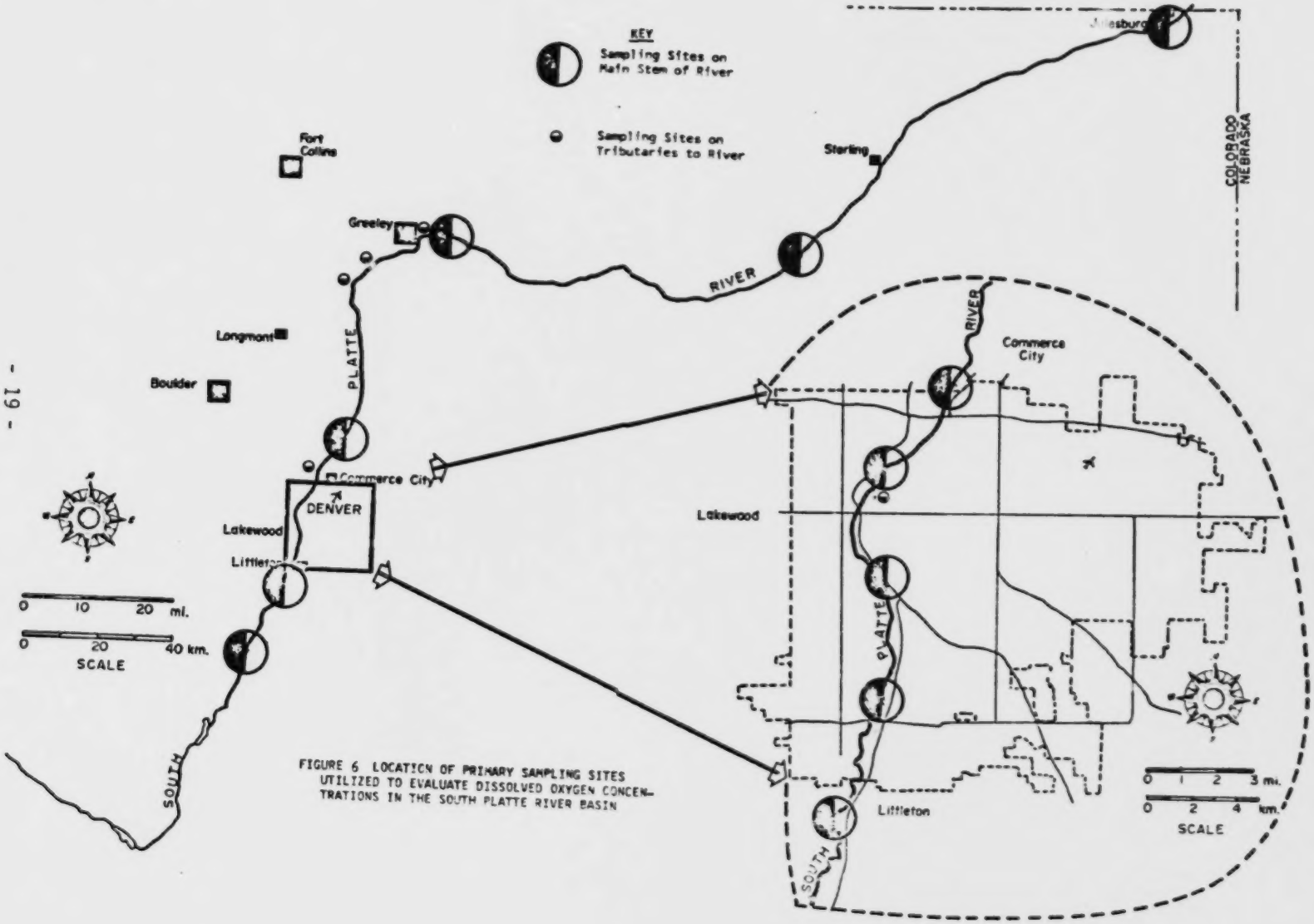


FIGURE 6 LOCATION OF PRIMARY SAMPLING SITES UTILIZED TO EVALUATE DISSOLVED OXYGEN CONCENTRATIONS IN THE SOUTH PLATTE RIVER BASIN

FIGURE 7

Current Concentrations of Dissolved Oxygen (Median and Range) For South Platte River Basin in Colorado
Based on Selected Data

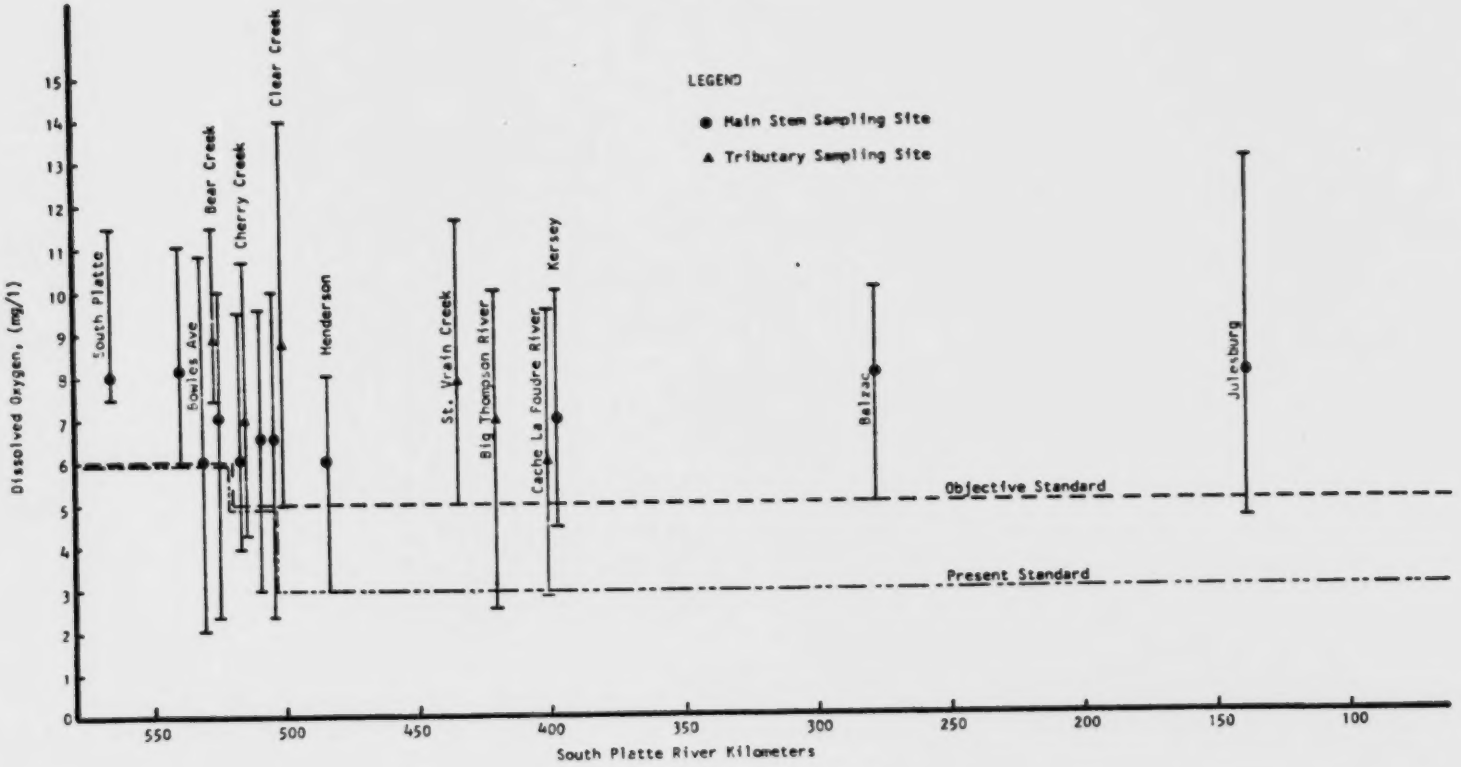


TABLE 6

Dissolved Oxygen Data - Analysis of Extremes

Station location	Objective Standard (mg/l)	Percentage of single measurements exceeding stated objective standard	
		1970-1972	1972
South Platte	6	0	0
I-470	6	0	0
Bowles	6	40	27
Bear Creek	6	0	0
Dartmouth	6	33	19
Alameda	5	26	23
Cherry Creek	5		0
19th Street	5	24	14
Franklin	5	36	27
Clear Creek	5	0	0
Henderson	5	26	0
St. Vrain Creek	5	0	0
Big Thompson River	5	14	0
Cache La Poudre River	5	10	0
Kersey	5	15	0
Balzac	5	0	0
Julesburg	5	0	0

Biochemical Oxygen Demand (BOD) Measurements

Sampling locations for the BOD measurements examined in this report are shown in Figure 8. The Biochemical Oxygen Demand (5-day) or BOD_5 increases from about 2 mg/l upstream of Denver to an estimated mean of 15 mg/l at Franklin Street (RK 505.3) and then "tails-off" to about 5 mg/l near the Nebraska state line (Figure 9). The station-by-station plots (Appendix A-4) show excursions to more than 10 mg/l at various main-stem and tributary stations between the Metropolitan area (Alameda Avenue - RK 517.4) and Kersey (RK 396.7) and these excursions are especially noted in more recent years. Based on an average flow at Henderson during 1972 of about 10 cms (350 cfs) and an average BOD_5 concentration of about 14 mg/l, the average BOD_5 load has been 12 metric tons per day ($2.6X10^4$ pounds) passing the South Platte River station at Henderson.

More recent BOD_5 measurements (1st quarter of 1973) indicate an increasing trend in BOD_5 load at the Henderson sampling site. Based on an average monthly flow of 9.2 cms (325 cfs) during the first quarter of 1973, the average BOD_5 load in the South Platte River at the Henderson sampling site was 21.5 metric tons per day ($4.7X10^4$ lbs per day). This load is approximately double the average BOD_5 load measured during 1972.

An analysis of BOD_5 data collected during January and February, 1973, at the South Platte River mainstem and tributary sampling sites upstream and downstream of the discharge from the Denver Metro Sewage Disposal District #1 Plant (plus BOD_5 effluent data from the plant) indicated that the increased BOD_5 concentrations at the downstream Henderson sampling station were due primarily to increased organic loads imposed by the sewage treatment plant discharge. If overall improvement of the quality of the South Platte River is to occur, a distinct improvement in the treatment capability of the Denver Metro Sewage Disposal Plant must be achieved.

Data collected at the Julesburg station suggest that the quality of the South Platte River at this point (RK 140) has improved since 1968 as shown by a decrease in the BOD_5 concentration from 11 mg/l during peak concentration periods to about 5 mg/l at peak periods in 1971, 1972, and the first quarter of 1973. Based on an average flow during 1972 of approximately 6.5 cms (230 cfs) and an average BOD_5 concentration of 2 mg/l the BOD_5 load averaged about 1.1 metric tons per day ($2.5X10^3$ pounds per day) in 1972.

Peak BOD_5 concentrations tend to occur during the winter months at sampling locations downstream of Henderson (downstream of RK 485.5). Similar peaks in BOD_5 concentrations at "metropolitan" stations upstream of Henderson appear to be inversely related to flow and not influenced by the same industrial processes common to the lower South Platte River drainage.

No BOD_5 standards are in existence or proposed for the South Platte River Basin. BOD_5 concentrations have been historically utilized as a convenient measure of oxygen-demanding loads introduced by major dischargers to the South Platte River System. The "Broad Objectives" of the South Platte Accomplishment Plan have been written in terms of BOD_5 load reductions of

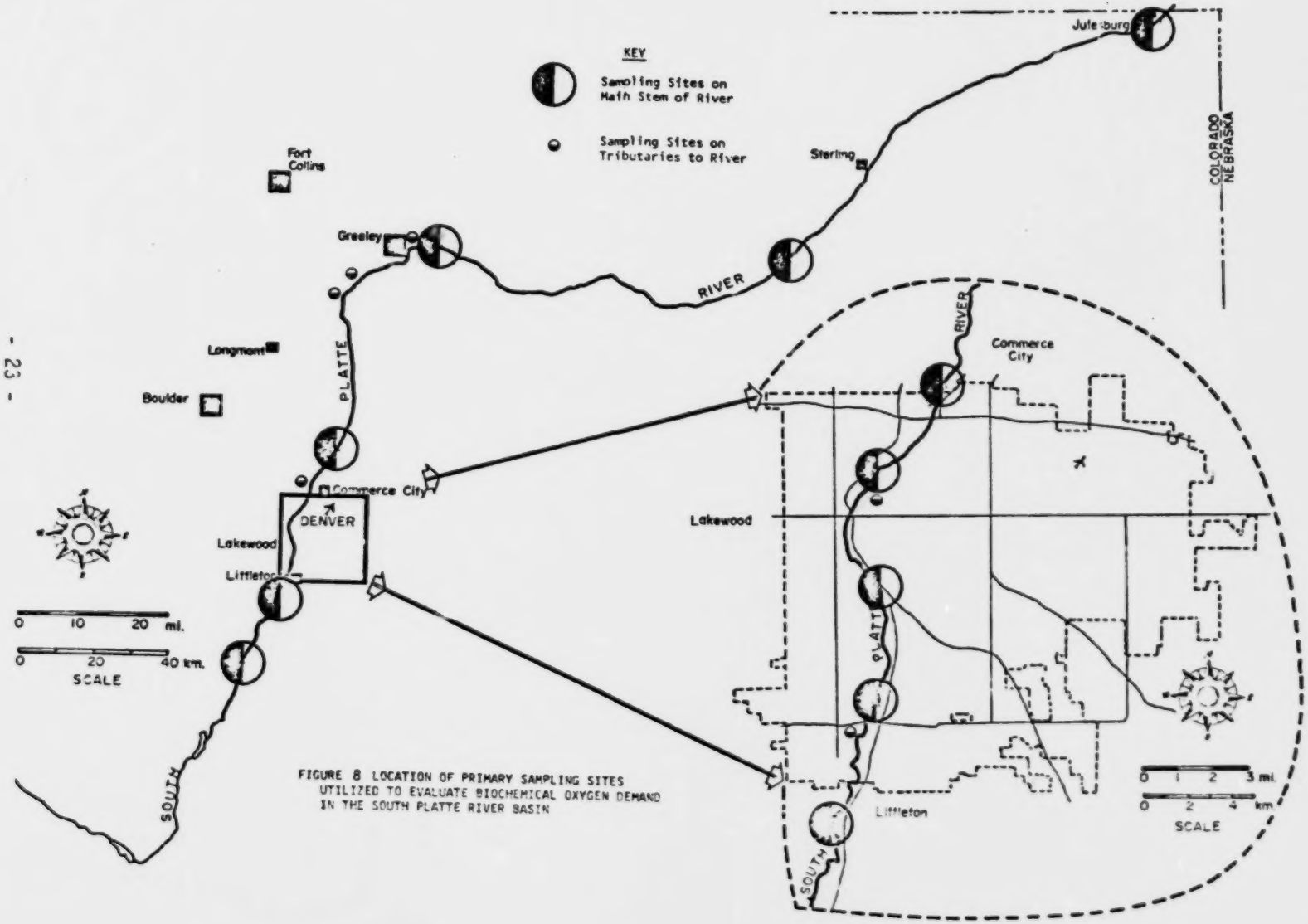
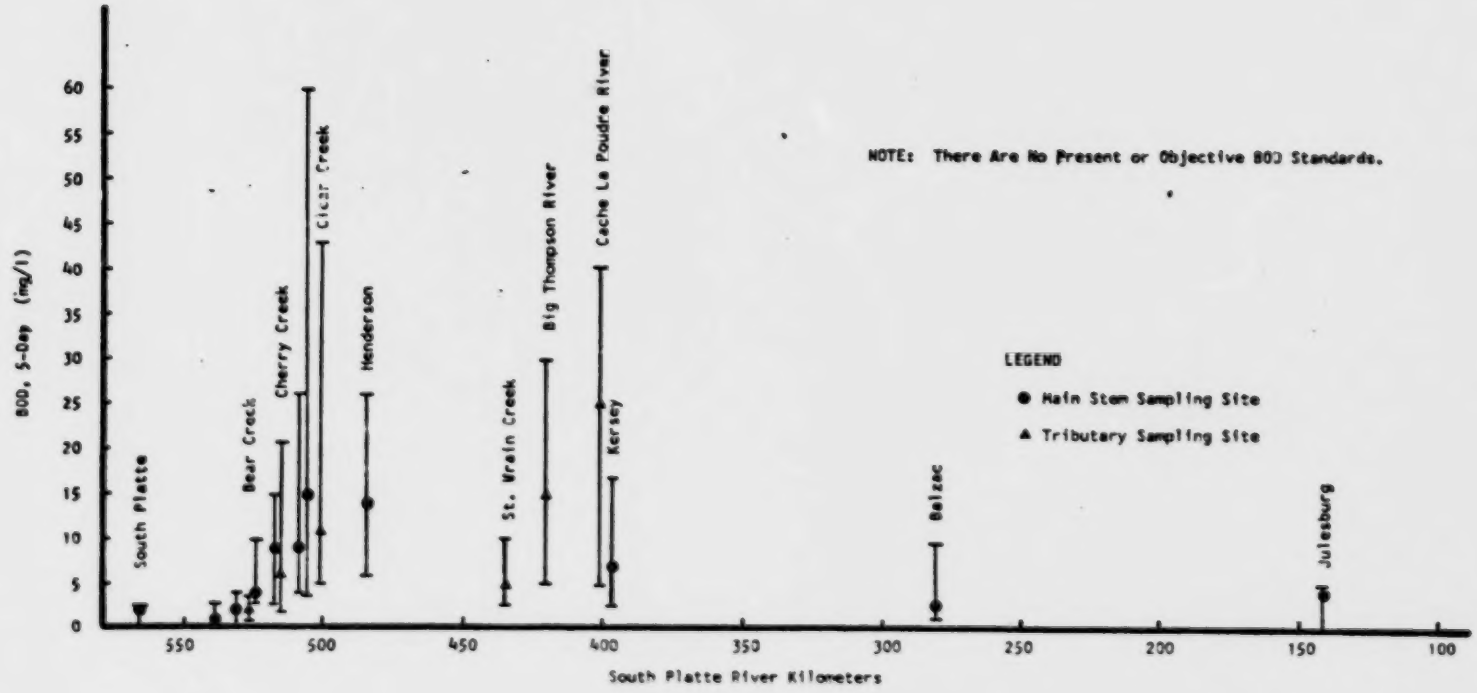


FIGURE 8 LOCATION OF PRIMARY SAMPLING SITES UTILIZED TO EVALUATE BIOCHEMICAL OXYGEN DEMAND IN THE SOUTH PLATTE RIVER BASIN

FIGURE 9

Current Concentrations of 5-day Biochemical Oxygen Demand (BOD_5-Median and Range) For South Platte River Basin in Colorado

Based on Selected Data



$4X10^4$ pounds per day (18 metric tons per day) by 1972 and $9.5X10^4$ pounds per day (43 metric tons per day) by 1976.

The full impact of BOD_5 load reductions of this size cannot be measured by the existing long-term water quality surveillance stations since the present BOD_5 loads at some of these stations are at least an order of magnitude less than the proposed reduction. For example, average BOD5 loads in 1972 are estimated to be 12, 11.1, 2.0, and 1.1 metric tons per day at Henderson, Kersey, Balzac, and Julesburg, respectively. It is suggested that major reductions in BOD_5 loadings will have to be monitored at or quite near their sources (municipal treatment plants and sugar beet processing plants).

Hydrogen Ion (pH) Measurements

Sampling locations utilized for analysis of pH measurements are shown in Figure 10. The acidity/alkalinity (pH) of the South Platte River Basin is not considered to be a strong function of any municipal or industrial discharges but rather to be controlled by runoff and recharge to the River system. As a result of its independence from "control," pH, along with temperature, as determined at the long-term stations, is considered to be a strong factor in determining appropriate stream classifications and subsequent quantitative standards whenever these classifications are strong functions of the hydrogen ion content and temperature of the water.

Present standards require adherence to a 6.5 to 8.5 (S.U.) range from the headwaters of the South Platte River to York Street (RK 504.4). Downstream of York Street the range is increased to 5 to 9 (S.U.). The present standards have not been exceeded on the acid side (<7.0 S.U.) at the long-term stations and those excursions over the basic side (>7.0 S.U.) might all be related to periods of rapid snow melt or otherwise rapid runoff (Figure 11).

The standards objectives would lower the upper bound from 8.5 to 8.3 (S.U.) in the stream reach providing for body contact recreation (Source to Englewood - RK 523.0) and would raise the lower bound from 5 (S.U.) in the lower reaches to 6 (S.U.). No significant problems are envisioned with the more restrictive bounds except in the cases of Cherry Creek and Clear Creek where some limitations on selected effluents may be necessary to insure maintenance of the South Platte and the appropriate tributary classification.

Temperature Measurements

Sampling locations utilized for analysis of temperature measurement are also shown in Figure 10. Along with the hydrogen ion content (pH), the temperature range of the South Platte River and its tributaries is not considered to be a strong function of any point-discharges, at least not as far as the quality of the river system is represented by data from the long-term stations. Discharges with the potential to affect the temperature of the South Platte River are thought to be those associated with three power plants (Arapahoe, Zuni, and Cherokee) the Martin Marietta facility discharging to Brush Creek, and, perhaps the Coors facilities, discharging to Clear Creek.

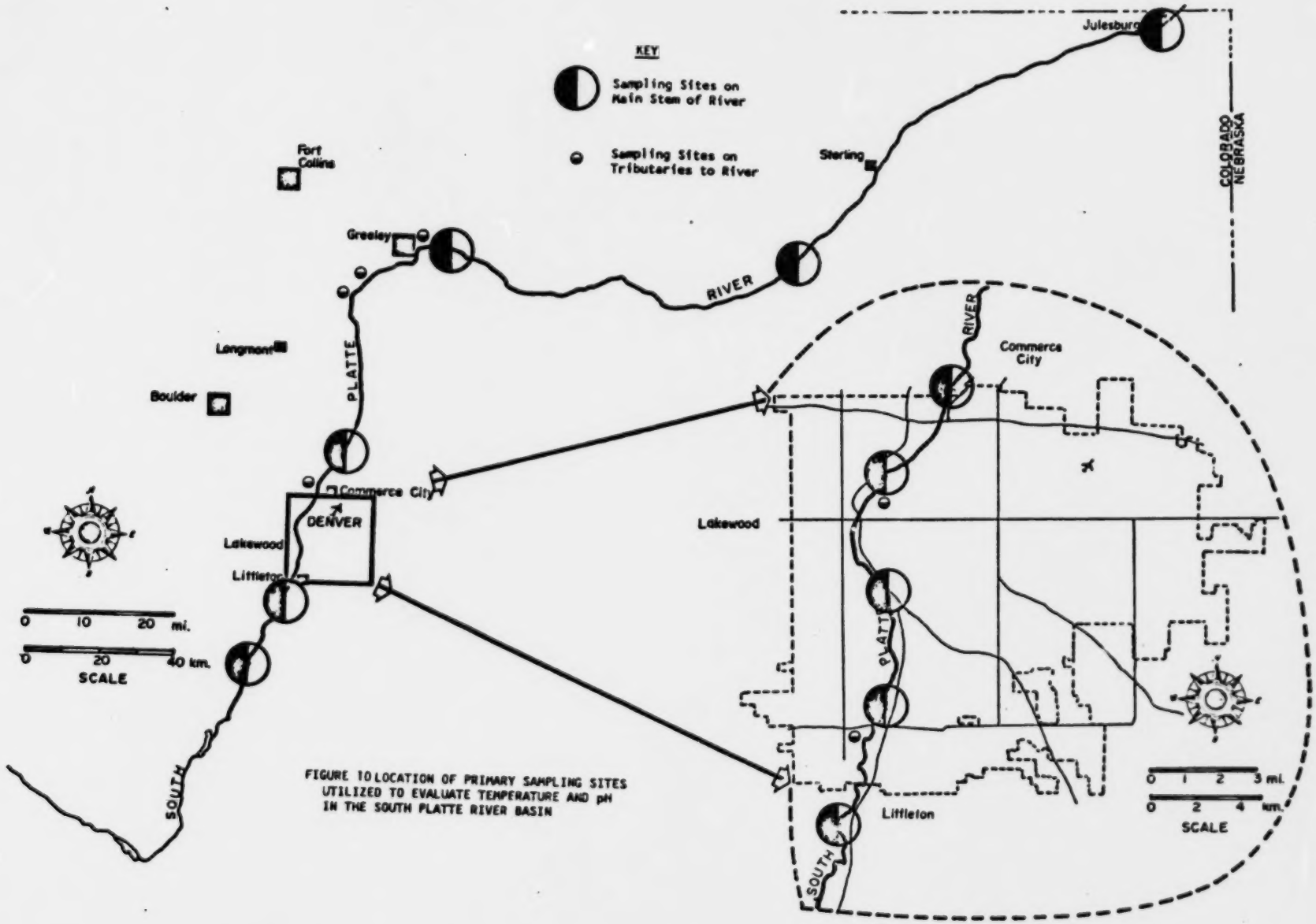
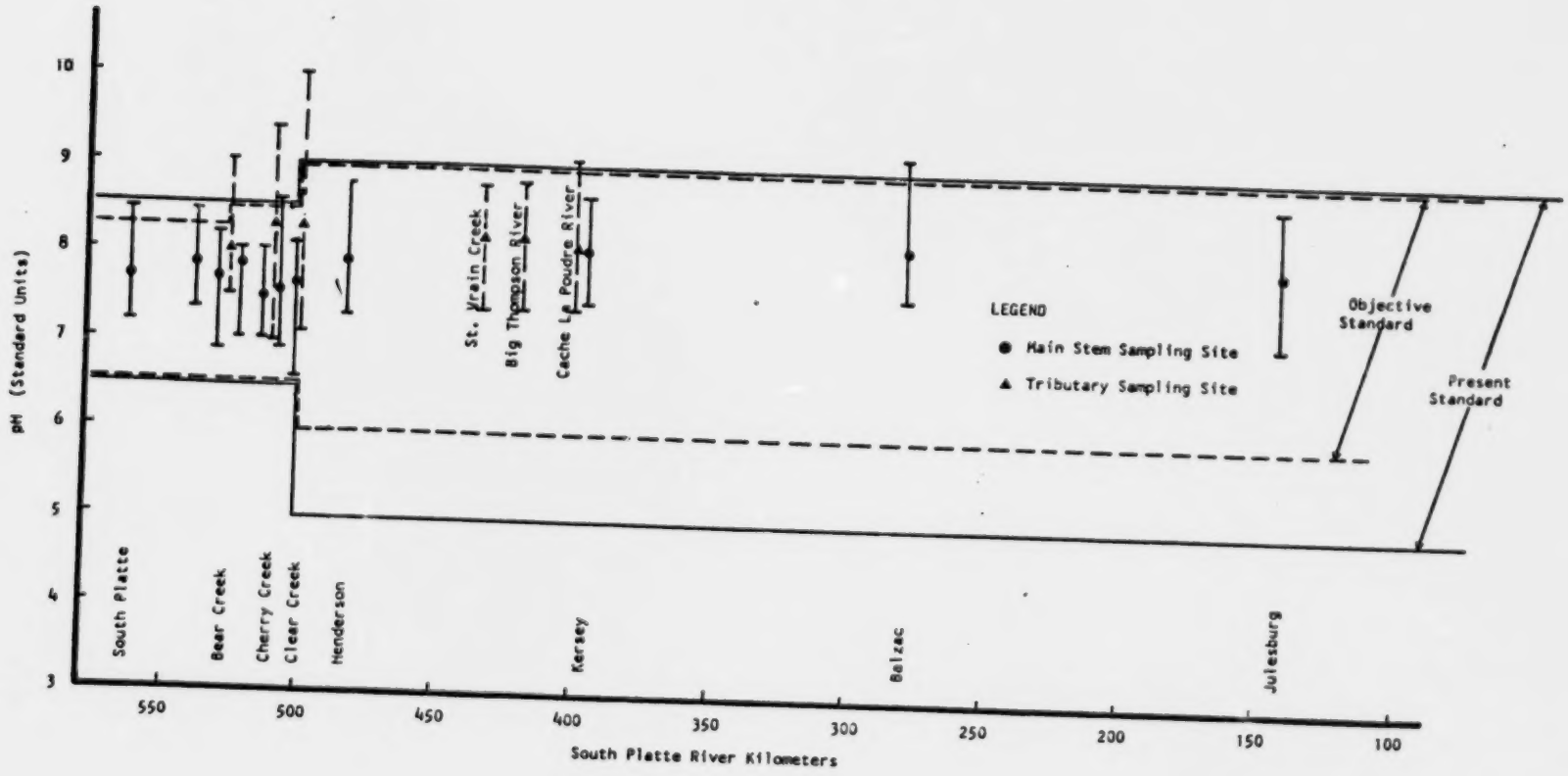


FIGURE 10 LOCATION OF PRIMARY SAMPLING SITES UTILIZED TO EVALUATE TEMPERATURE AND pH IN THE SOUTH PLATTE RIVER BASIN

FIGURE 11

Current Concentrations of Hydrogen Ion (pH)(Median & Range) for South Platte River Basin in Colorado

Based on Selected Data



The summary graph (Figure 12) shows a slight tendency of the upper bound (of the temperature range) to rise from about 21° C (70° F) to about 24° C (75° F) as the River moves through the Denver metropolitan area. At Balzac (RK 280.0) the temperatures range up to about 29° C(85° F) but this high value is presumed to be a function of the topography, climate, and amount of water present in the vicinity of this sampling station.

The present water quality standards for the South Platte River set an upper temperature limit of 21° C(70° F) upstream of Exposition Avenue (RK 513.4) and 32° C (90° F) downstream from Exposition Avenue to the State Line. With the exception of values of about 22° C (72° F) that have been measured on occasion at Bowles Avenue (RK 530.7) and Dartmouth Avenue (RK 524.1), no problems have been encountered in meeting these temperature criteria. Of course the data are insufficient to measure the short-range rise in temperatures near specific outfalls to determine whether abrupt changes in temperature are caused by such outfalls. The apparent increase in temperature from 1970 to 1971 suggested by the station-by-station plots in Appendix A-6 is thought to be related to the decrease in average annual flow occurring from 1970 to 1971.

The standards objectives could change only the upper bound on the coldwater fishery portion of the South Platte (upstream of Exposition Avenue - RK 518.4) from its present limit of 21° C (70° F) to 14.5° C (58° F) (suitable for all cold water species). The long-term data indicates that such a standard may be too strict for the upper reaches of the South Platte River if the fish species introduced or desired are sensitive to the higher temperatures likely to occur in the River. It may be appropriate to instead place an upper bound of 18° C (65° F) (suitable for brown trout) on the upper reaches.

Nutrient Measurements

A selected amount of nutrient data were reviewed to ascertain the quality of the main stem of the South Platte River in terms of concentrations of nitrates (as nitrogen), phosphate (as phosphate), and ammonia (as nitrogen).

Nitrate concentrations showed a tendency to fluctuate somewhat sporadically throughout the river reach. Concentrations increased almost 15 fold to about 3 mg/l (as N) as the river passed through the Denver Metropolitan area (Figure 13). Near the Nebraska State Line a reduction in nitrate concentration to about 1.5 mg/l (as N) was observed. Unusually high concentrations (3 to 4 times normal) were measured at all stations during mid-1970 (see Appendix A-7). Even with this significant increase the nitrate concentrations have remained well below the recommended limit of 10 mg/l (as N) for drinking water purposes. This does not negate the fact that the presently measured nitrate concentrations may be a signficant factor in the production of algae growths in the South Platte River.

Phosphate concentrations rise from about 0.1 mg/l (as total PO_4) measured upstream from Denver (RK 564.5) to about 7 mg/l downstream at the Henderson station (RK 485.5). Concentrations then gradually decrease to about 0.5 mg/l (T-PO_4) as the Nebraska State Line is approached. Concentrations of total phosphorus above 0.1 mg/l are generally thought to significantly enhance the

FIGURE 12

Current Range in Temperature for South Platte River Basin in Colorado

Based on Selected Data

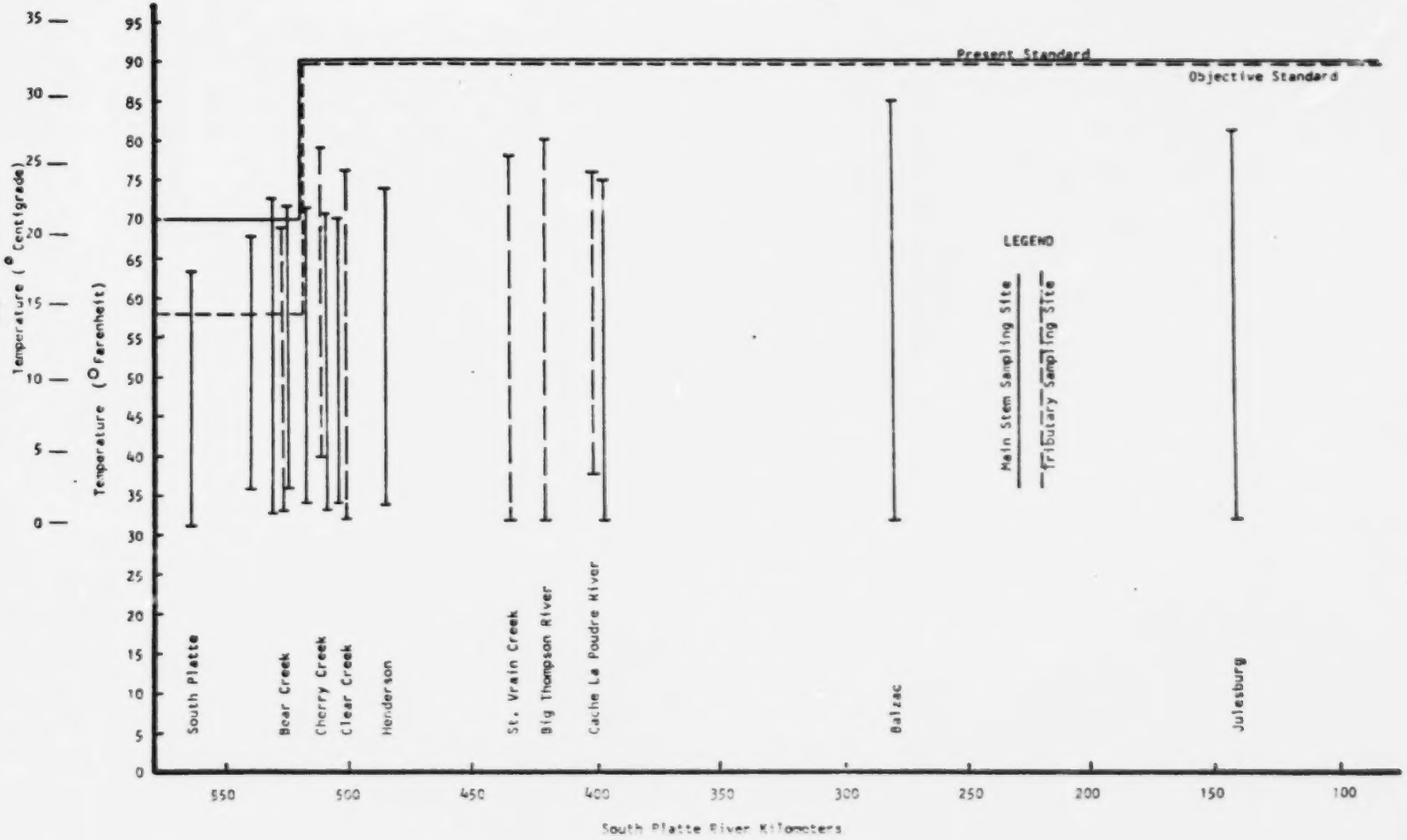
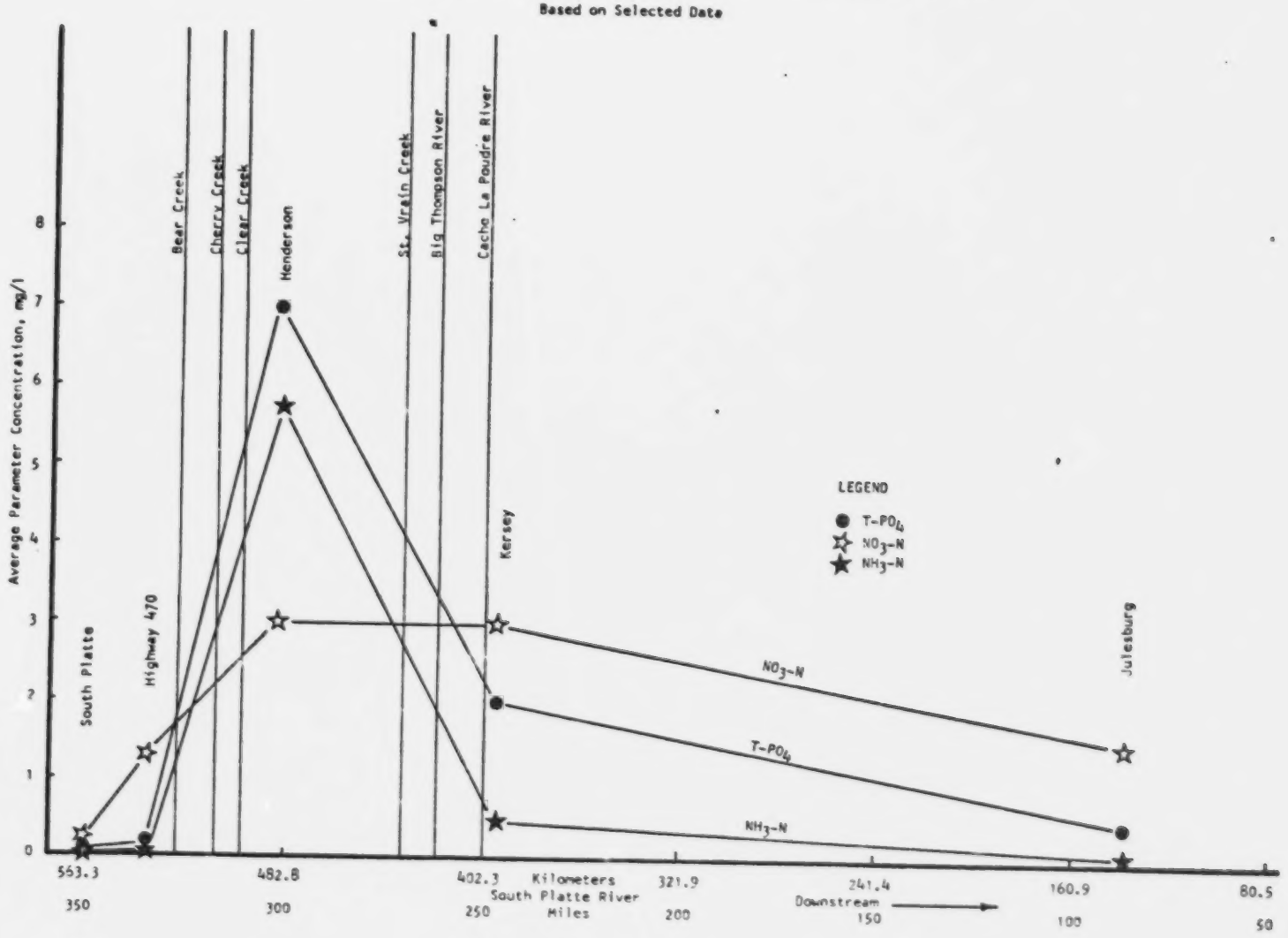


FIGURE 13

Current Concentrations of Nutrients (PO_4, NO_3, NH_3) For South Platte River in Colorado

Based on Selected Data



production of algae in streams and lakes (assuming other necessary growth factors are available).[5] It is evident that control of phosphorus is required in the South Platte River in and below the Denver Metro Area if an excessive growth of nuisance algae is to be prevented since nitrogen concentrations and temperatures are suitable for algal growth. An upward trend in phosphate concentrations has been observed at Henderson and Kersey (RK 485.5 and RK 396.7, respectively) since 1970. The factors which have produced this increase are not completely identifiable, but they may relate to the increase in organic waste discharge from the Denver Metro Sewage Disposal District #1 Plant which was discussed in an earlier section dealing with BOD_5 concentrations in the South Platte River.

Ammonia concentrations also increase appreciably as the South Platte River passes through Denver (from 0.04 mg/l to 5.8 mg/l) (as nitrogen) and then decrease downstream to the State Line (0.1 mg/l)(as N). Significant peaking in ammonia concentrations has been observed during the winter and spring seasons. However, in 1972 the ammonia concentrations at Henderson (RK 485.5) did not drop through the summer to the extent noted in the past. The normal decrease from winter to summer is from about 12 mg/l NH_3 (as N) to about 1 mg/l NH_3 (as N) but during the 1972 summer season the NH_3 concentration remained at about 10 mg/l (as N). Increasing effluent flow from the Denver Metro Sewage Treatment Plant located at RK 502.4 may have contributed to the increased NH_3 concentrations observed in 1972 at the Henderson site (RK 485.5).

Concern has been expressed over possible ammonia toxicity in the South Platte River and the possible need for ammonia removal at the Denver Metro Plant. Recent research indicates that only the un-ionized fraction (NH_3) of ammonia is toxic to fish, and that the highest concentration of un-ionized ammonia which apparently will not cause any adverse effects is 0.025 mg/l NH_3 as NH_3 (0.0206 mg/l NH_3 as N)[6]. The un-ionized fraction of total ammonia is, in large part, a function of pH and temperature, with the fraction increasing as pH and temperature values increase.

Based on long term average values for pH (8.0) and temperature (highs near 20°C) at the Henderson sampling site (located approximately 17 kilometers downstream from the Denver Metro Plant discharge), the concentration of total ammonia ($NH_3 + NH_4^+$) in the river must not exceed 0.54 mg/l NH_3 as N if the toxic un-ionized ammonia fraction (NH_3) is to remain below the recommended limit of .0206 mg/l NH_3 as N (variables other than pH and temperature are considered to be insignificant in this calculation). Since the river contains an average concentration of approximately 6 mg/l total NH_3 as N at this location, there clearly exists a great potential for serious impairment of the warm water fishery in this stream reach. These facts present a strong case for the adoption by the Denver Metro Sewage Treatment Plant of additional treatment facilities designed for a high degree of ammonia removal.

5/ Proposed Criteria for Water Quality, Vol. I, U.S. Environmental Protection Agency, Washington, D.C., October, 1973.

6/ The Proposed Criteria for Water Quality published by the U.S. EPA Agency, October, 1973, page 95, states: "The acceptable maximum concentration of un-ionized ammonia in water is 0.02 mg/l."

Comparison of Data from Short-Term and Long-Term Sampling

To determine if there were significant differences in measurement of parameters between infrequent, long-term sampling and intensive, short-term sampling, an examination and comparison of sample results under both conditions was made at the 19th Street sampling location (RK 510.6). These results are presented in Figures 14 through 19. In general the figures show that long-term data (regular semi-monthly sampling by the Denver County Health Dept.) and short-term data (daily sampling coordinated by the Denver Regional Council of Governments (DRCOG) study program) are in fairly close agreement throughout the April-July comparison period for dissolved oxygen (DO) and fecal coliform parameters. The BOD_5 values also agree closely during the latter period of comparison (June-July), but during the earlier period (April-May) the long-term data is about 50% less than the short-term data. Note also, in Figure 14, the low concentrations of dissolved oxygen (<4 mg/l) which are frequently encountered at the 19th Street sampling location.

Comparisons were also made between samples collected at frequent (4 hour) intervals during the day and samples collected only once during the same day at the same location. It was found that significant variations in water quality (particularly BOD_5 concentrations) occurred throughout the day at the 19th Street sampling site (See Figures 17 through 19). The above results indicate that the long-term data (derived from semi-monthly grab samples) employed in this report does not always accurately reflect the existing stream conditions which would be observed through an intensive daily sampling program.

Adequacy of Data

The data presented and reviewed herein are almost all "long-term data," that is, they have been collected infrequently at widely-spaced stations. As such the data are moderately adequate. The representativeness of the data is considered questionable in the following areas:

1. The exact sampling locations are not well-defined and, as a result, the data are comprised of samples which may have been collected from different river mileage locations or under different mixing conditions.

2. The time of day for sample collection has not been consistent. DO samples may be significantly affected by this variable. (In some cases, this variation may be desirable).

3. Flow data for the sampling locations are not generally obtained at the time of sample collection.

4. Methods of measuring coliform bacteria vary from agency to agency.

As discussed earlier, these data are not collected in a manner (frequency or duration) to allow accurate evaluation of the potential to violate quantitative standards. In general, the weakness lies in the fact that the length of time that a specific concentration exists is not determined.

FIGURE 14

Comparison of Low versus High Frequency Measurement of Dissolved Oxygen Concentrations--19th Street Station (RK 510.6) South Platte River

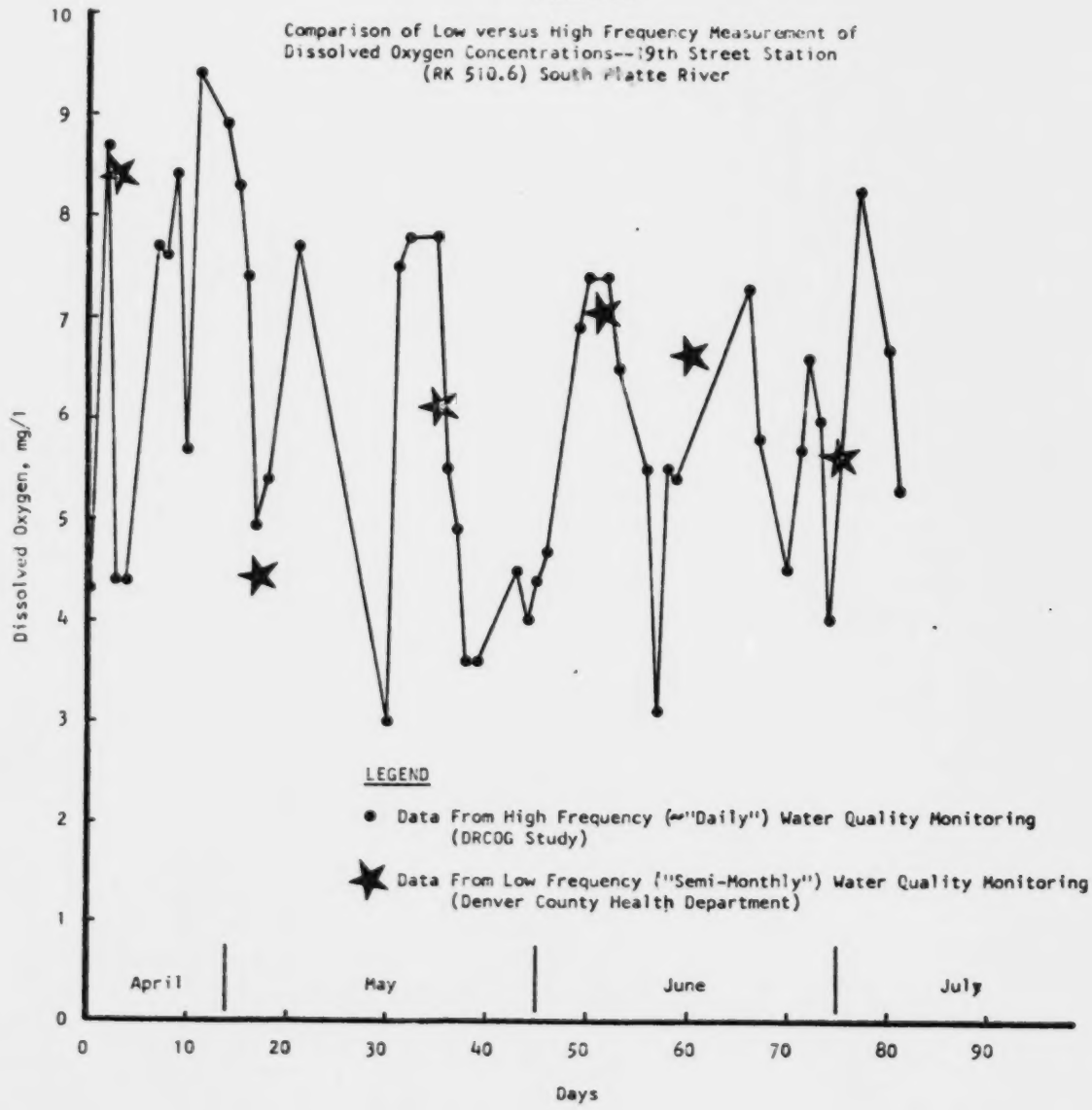


FIGURE 15

Comparison of Low versus High Frequency Measurement of
Fecal Coliform Bacteria Concentrations
19th Street Station (RK 510.6) South Platte River

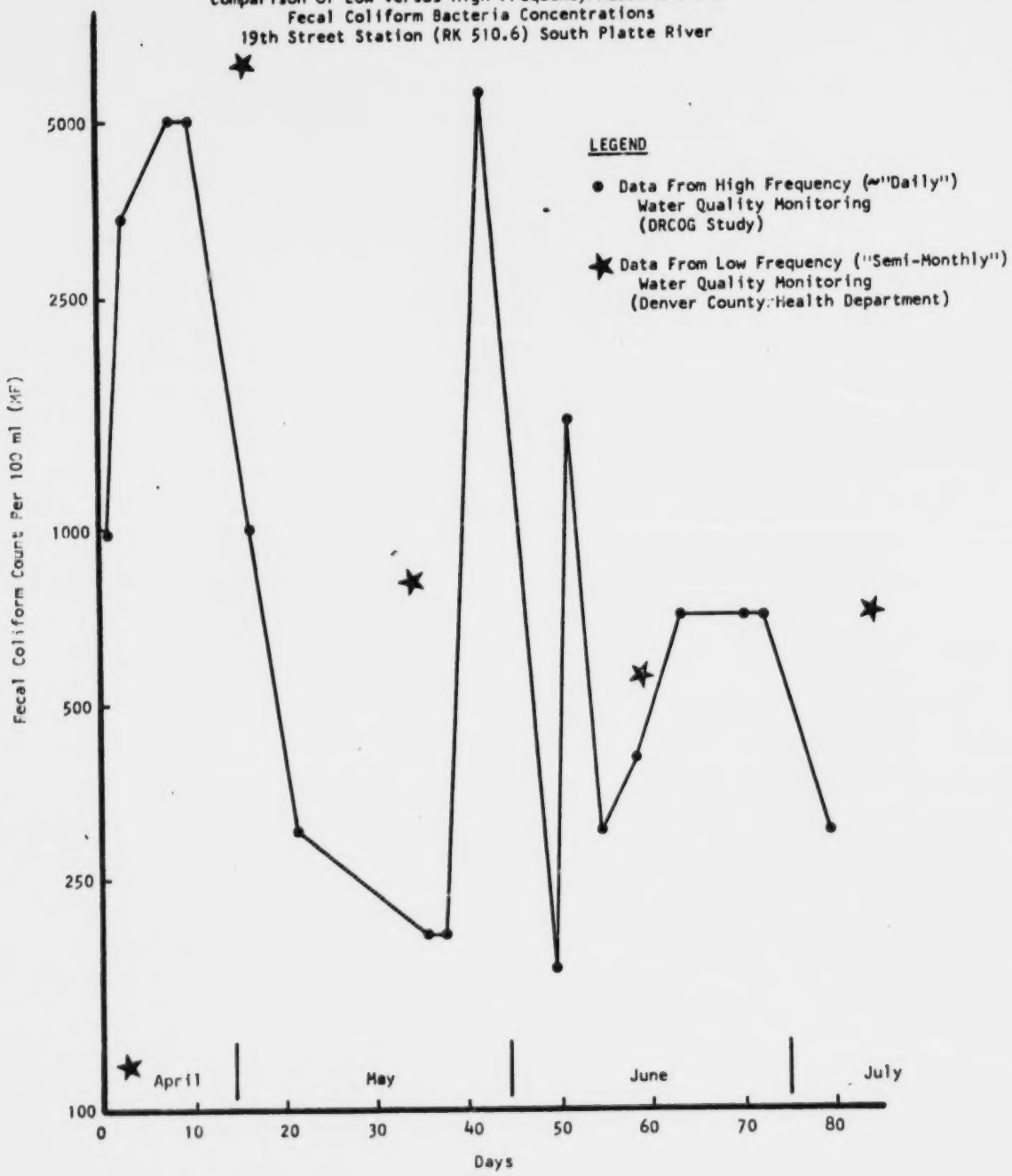


FIGURE 16

Comparison of Low versus High Frequency Measurement of Five-Day Biochemical Oxygen Demand Concentrations 19th Street Station (RK 510.6) South Platte River

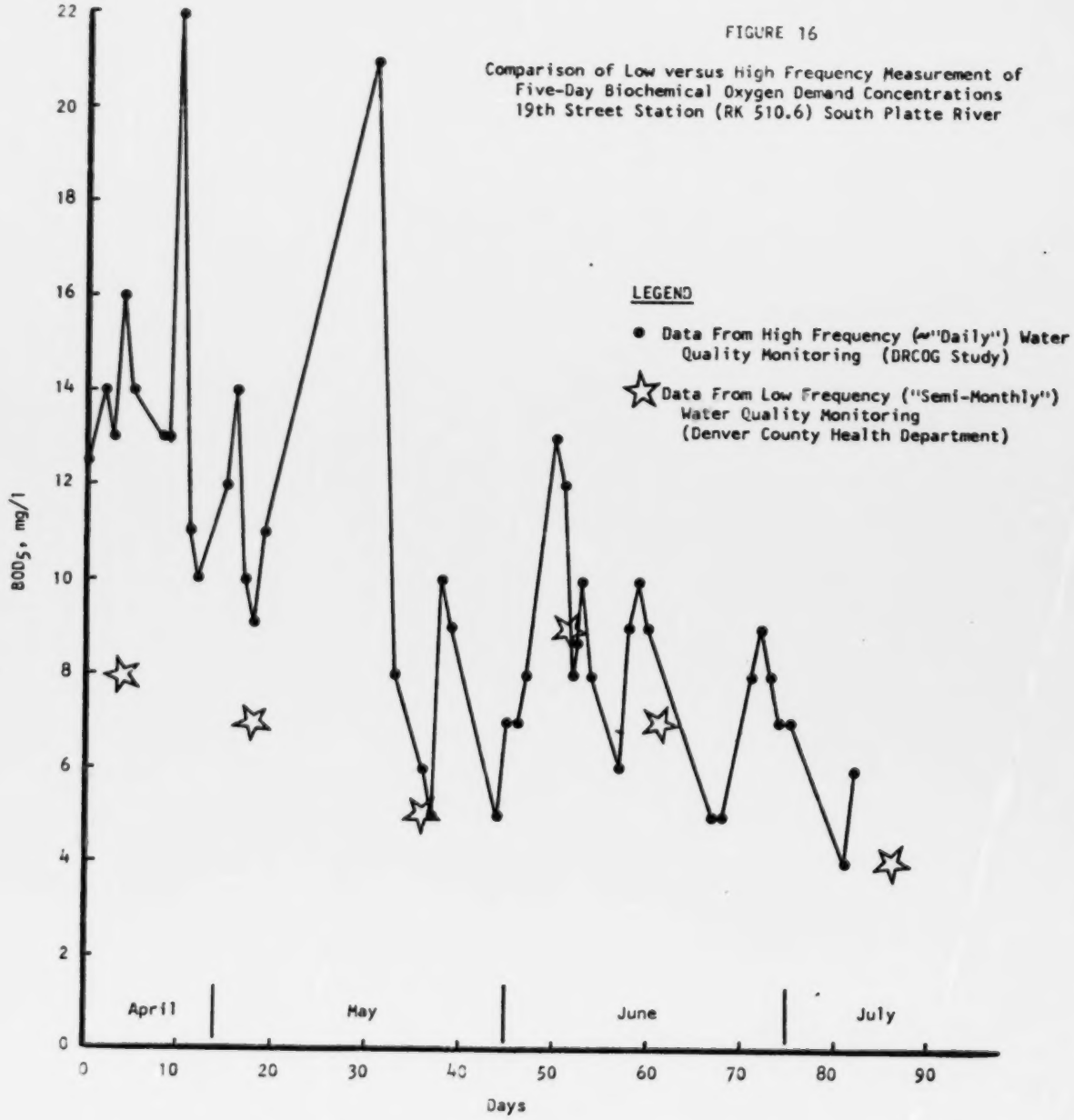


FIGURE 17

Comparison of Semi-Monthly versus Hourly Measurements of
Dissolved Oxygen Concentrations
19th Street Station (RK 510.6) South Platte River

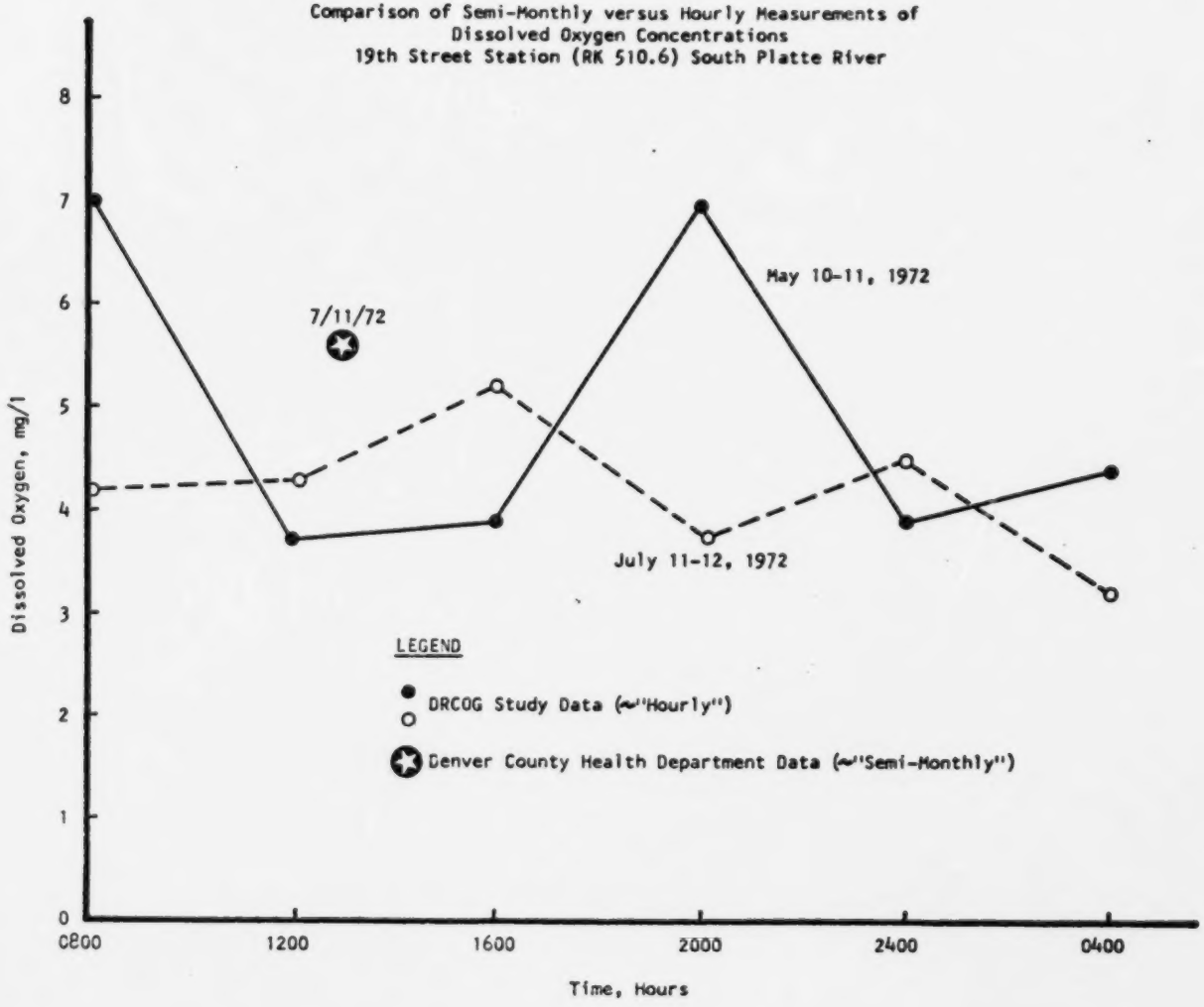


FIGURE 18

Comparison of Semi-Monthly versus Hourly Measurement of
Fecal Coliform Bacteria Concentrations
19th Street Station (RK 510.6) South Platte River

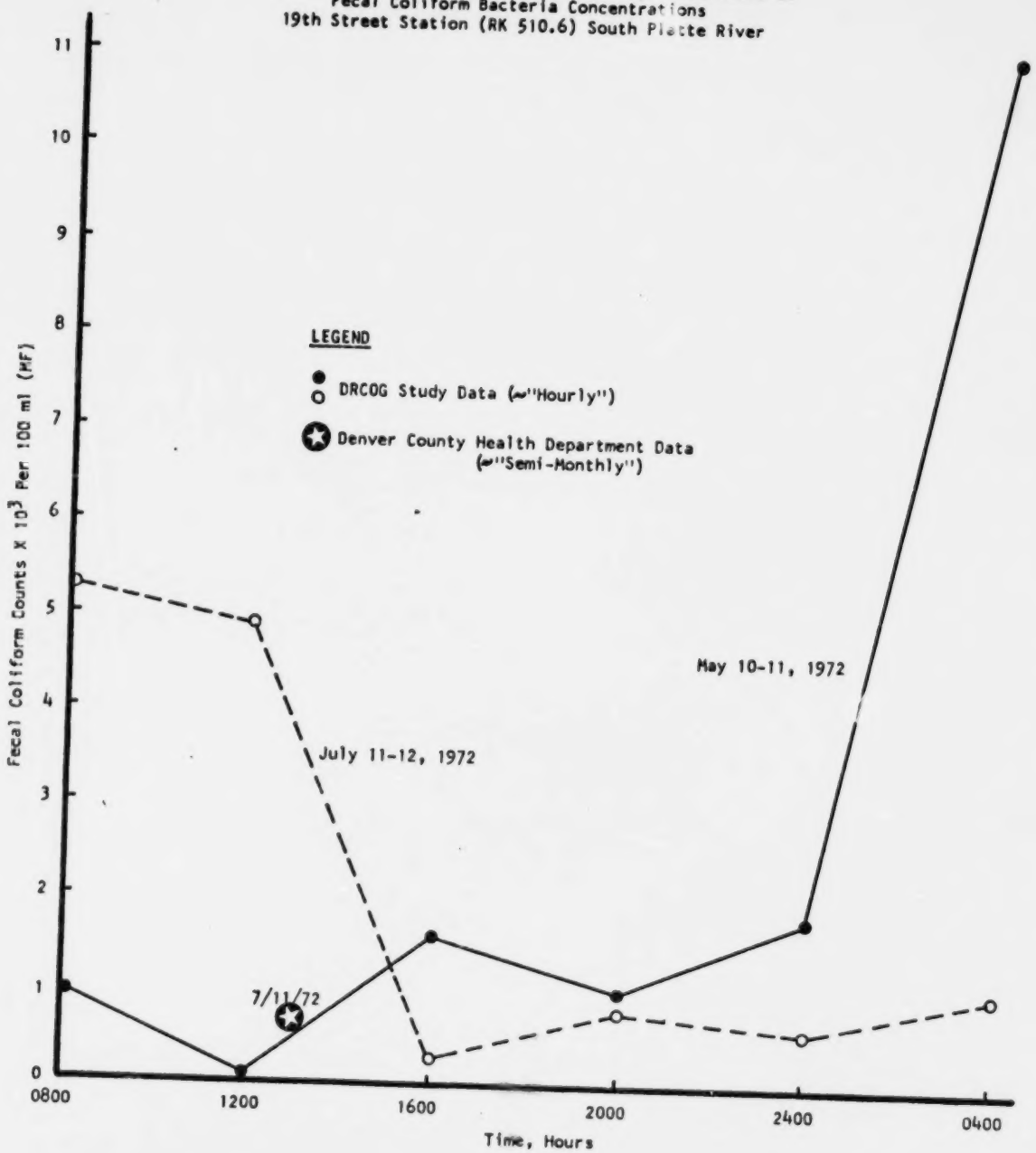
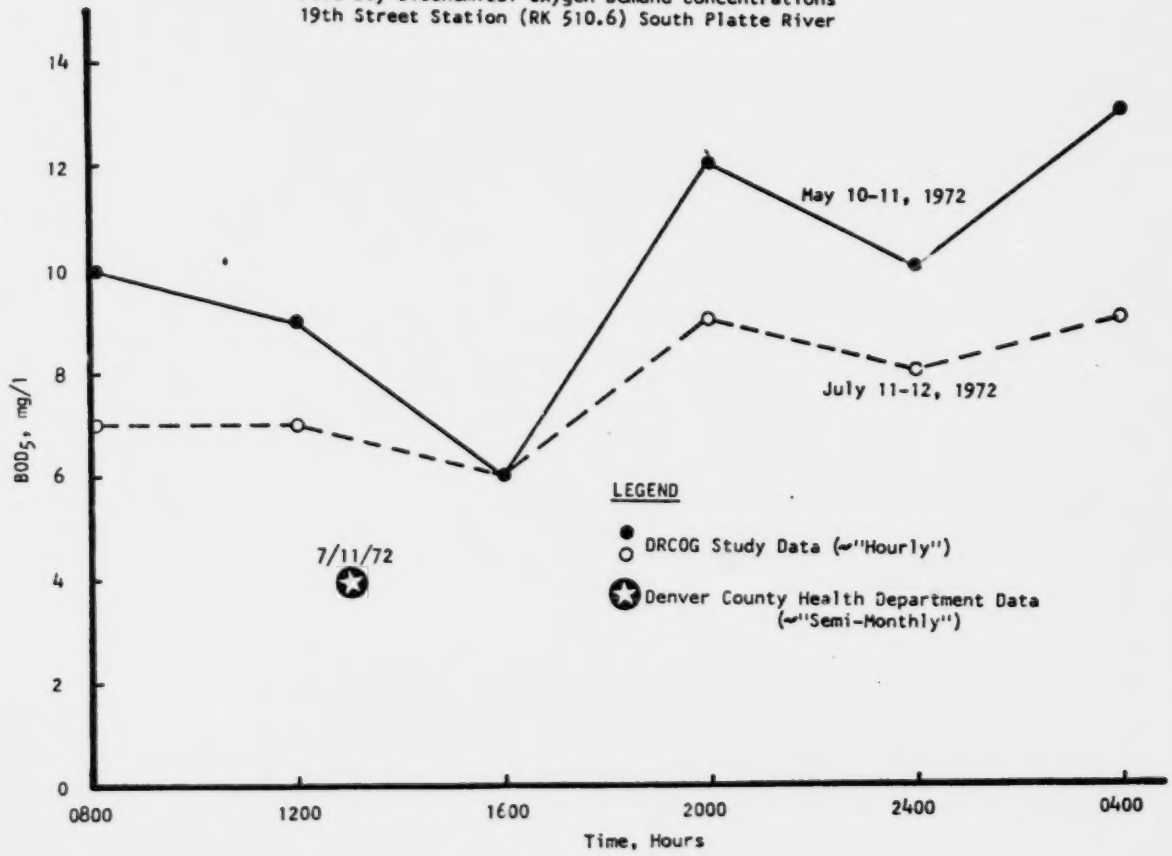


FIGURE 19

Comparison of Semi-Monthly versus Hourly Measurements of
Five-Day Biochemical Oxygen Demand Concentrations
19th Street Station (RK 510.6) South Platte River



Further, the present sampling network does not adequately identify sources of pollutants. For example, the network does not define the impact on water temperature of discharges from three power plants located on the South Platte River nor from a brewery located on Clear Creek or a manufacturing facility located on Brush Creek. The network does not facilitate the identification of contributions of contaminants from minor tributaries such as Lakewood Gulch and various storm sewers.

In addition, the present sampling network is not designed to quantify variables such as ground water inflow to the streams, the state of existing aquatic biota, non-point sources of pollution, or the role of sediment transport and deposition. Therefore accurate modeling of the entire river system is not presently feasible.

SUMMARY OF LONG-TERM MEASUREMENTS

Present Concentrations - Main Stem

The main stem of the South Platte River in Colorado undergoes deterioration as it passes through the Denver Metropolitan Area (RK 539.0 to RK 485.5). In terms of coliform bacteria, the highest concentrations are normally measured at the Franklin Street sampling location (RK 505.3), averaging about 550,000 total coliform organisms and 3000 fecal coliform organisms per 100 ml. Concentrations sporadically rise to as much as 100 times these median values. The dissolved oxygen content of the South Platte River also decreases from a median upstream value of about 8 mg/l to a median value of about 6 mg/l, with fluctuations of 2 mg/l as the River traverses the metropolitan area. The 5-day biochemical oxygen demand of the river increases through the metropolitan area to a median value of about 15 mg/l with fluctuations in excess of 25 mg/l. Temperature and pH data show only minor deterioration through the metro-area. Nutrient data (NO_3, PO_4, NH_3) reflect a deterioration, especially in phosphate and ammonia (to about 7 mg/l and 6 mg/l, respectively), not only through Denver but also downstream as far as Kersey, about 100 kilometers downstream of the metropolitan area.

The overall deterioration of the South Platte River is not relegated to just the reach immediately downstream from the major treatment plants, but rather occurs throughout the Metro area.

Long-Term Trends - Main Stem

Long-term trends in water quality appear to be associated with a decrease in coliform bacteria in the River since 1966 complicated by a disturbing upward trend in concentrations measured in the metropolitan area recently. Dissolved oxygen concentrations have varied in a cyclic yet unpredictable fashion throughout the period of record and though there is some sign of decreasing water quality recently, equally low values of D.O. have occurred in periods of the past. BOD_5 concentrations have remained about the same at most locations through the period of record except for the Henderson location which has shown a doubling in concentration during the first quarter of 1973. BOD_5 concentrations at several locations within metropolitan Denver have also shown sporadically high values in the more recent data (1972).

To a certain extent, improvements in the water quality of the South Platte River that appeared imminent in 1970 (when compared to 1966-1968) have not completely materialized.

Tributaries

The bacteriological quality of the major tributaries to the South Platte River improved over the period of record. The dissolved oxygen concentrations fluctuated in a manner similar to that of the South Platte itself whereas the BOD_5 concentrations showed a minor tendency to decrease. Of those tributaries for which data were reviewed, the Cache La Poudre carried the highest median concentrations of bacteria and BOD_5 and the lowest median D.O. concentration. Clear Creek, by virtue of sporadic excursions of increasing bacteria and BOD_5 concentrations, also warrants designation as a continuing deterrent to achievement of high quality water in the South Platte River Basin.

Relationship of Present Quality to "Obective" Classifications

In order to meet the water quality standards or "objective" classifications herein proposed for the South Platte River Basin, the following changes in present water quality must be achieved:

1. Average total coliform bacteria concentrations must be reduced by an order of magnitude or more in both the South Platte River through Denver and in all major tributaries downstream of Cherry Creek.

2. Average fecal coliform bacteria concentrations must be reduced by a factor of three in both the South Platte River through Denver and the Big Thompson River and reduced by a factor of 20 in the Cache La Poudre River.

3. Average dissolved oxygen concentrations must be generally increased to prevent excursions of long duration below the "objective" standards of 6 and 5 mg/l. This may require a 20 percent increase in DO or implementation of methods to reduce the sizable fluctuations (downward) of disssolved oxygen.

4. In order to achieve the changes listed above, the BOD_5 concentrations will have to be reduced.

Since the data herein presented and summarized continue to be collected infrequently, and since variations in concentrations are functions not only of controllable discharges but also of the season, stream velocities and flow quantity, channel configuration, mixing, and precipitation/recharge, it will not be easy to ascertain whether improvements in water quality are achieved by just reviewing the long-term data. However, monthly review of long-term data can provide a rough indicator of permanent changes in water quality. Such changes must then be proven by quantifying the previously mentioned variables of season, velocity and flow quantity, channel configuration, mixing, and duration of concentration.

EFFLUENTS TO THE SOUTH PLATTE RIVER AND TRIBUTARIES

The South Platte River is estimated to receive a total of 17.4 cms (~400 MGD) from industrial and municipal discharges. This amount is comprised almost equally of discharges from municipal water and waste water treatment plants and industries (see Table 7A). While the discharge amount is somewhat low compared to discharges from industrialized areas in the East and Midwest, the amount estimated as being discharged to the South Platte River system is approximately equal to the four year average annual flow (1969-1972) near the State Line at Julesburg (~20 cms or ~700 cfs). Therefore, the discharges can have a significant impact on the quantity and quality of the South Platte River.

Table 7B lists the known discharges to the South Platte River System along with water quality monitoring stations and tributary locations. The industrial data are derived from applications to EPA for discharge permits. The vast majority of the industrial discharges come from 24 facilities, each having estimated flows equal to or in excess of 0.09 cms (~2.0 MGD) (see Table 7C). The Metropolitan Denver Waste Water Treatment Plant is estimated to account for over 50 percent of the flow from the municipal discharges (5.09 cms or 116 MGD).

It seems reasonable to hypothesize that since water quality degradation of the South Platte River occurs primarily as increases in coliform bacteria and organic material, municipal discharges share a large part of the responsibility for the degradation.

FUTURE WATER QUALITY SURVEILLANCE PROGRAM

EPA-Region VIII, proposed a comprehensive water quality surveillance system for the South Platte River Basin in March of 1973.7/ The proposed system included 23 main stem stations and 34 tributary stations. Of the total of 57 stations, 25 were occupied at the time of the March, 1973 report. Recent decreases in funding have forced an intensive review of all comprehensive monitoring systems and, therefore, the earlier plan is herein modified and reduced to its essentials.

It is felt that the major objective of the water quality surveillance network will be to evaluate ambient water quality against water quality standards. Detection of "spills" or accidental releases will be the responsibility of point source monitors as opposed to the surveillance network. Measurements to define the fate of most point and nonpoint discharges must be conducted as short term (<1 year) surveys. Mixing relationships at

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7/ "Water Quality Monitoring Plan in South Platte River Basin, Colorado and Wyoming," Surveillance Branch, Surveillance and Analysis Division, U.S. Environmental Protection Agency, Region VIII, March, 1973.

TABLE 7A

Major Classifications of Point-Source Discharges

To The South Platte River Basin

Facilities	Total Discharges MGD	CMS
Water Treatment Plants	9.2	0.40
Waste Water Treatment Plants	184.2	8.09
Industry	203.5	8.93
TOTAL	396.9	17.4

TABLE 70

Discharges of Record in the South Platte River Basin as of 1973

Discharges to South Platte River - Main Stem

Name	Type of Facility	Location PM	Location RM	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting water quality
WQS[1] - South Platte Colorado		350.8	564.5			
Kassler Water Treatment Plant Denver Water Board	Domestic Water	339	548.5	0.17	7.46×10^{-3}	(solids)
Martin Marietta Corp Deer Creek enters @ 330.5 through gravel pit Plum Creek enters @ 335.2	Mfg. Resources	331.1/2.	548.9/ 543.2	0.65	24.1×10^{-3}	Sewage, Metal Plating (solids, BOD_5, Temp.) into Brush Creek
WQS - Interstate Highway 470 Bridge	Gravel	334.9	539.0			
Peter Kiewit & Sons WQS - Bowles Ave Bridge	Construction	330 329.9	531.1 530.7	0.3	13.2×10^{-3}	
Englewood Water Treatment Plant	Domestic wtr.	328	527.8	0.28	12.3×10^{-3}	(solids)
Littleton waste Water Treatment Plant see Bear Creek enters @ 326.4	Sewage	327.6	527.2	5.2	.228	(solids, BOD_5)
Public Service Company (Arapahoe Station) WQS - Dartmouth Ave. Bridge	Power Gen. coal	328 326.7	527.8 524.2	1.3	57.1×10^{-3}	(solids, Temp.)
Englewood waste Water Treatment Plant	Sewage	325.1	521.2	8.6	.377	(BOD_5, solids)
WQS - Alameda Ave. Bridge		321.8	517.4			

[1] WQS = Water Quality Station

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TABLE 7D

Discharges of Record In South Platte River Basin As Of 1975

Discharges to South Platte River - Bear Creek (RM 109.4 on South Platte)

Name	Type of Facility	Location RM	Location SV	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting water quality
Public Service Company Water Treatment Plant, Evergreen		114.4	435,3/47.1	0.03	1.3×10^{-3}	
Public Service Company Filter Water Treatment Plant, Evergreen		114.4	435,3/45.3	0.03	1.3×10^{-3}	
Evergreen Waste Water Treatment Plant	Sewage	114.4	435,3/43.2	0.2	8.76×10^{-3}	(Solids, BOD_5, Bacteria)
Public Service Company-Water Treatment Plant, Littridge		114.4	435,3/38.2	0.003	$.14 \times 10^{-3}$	
AGS - Jefferson-Arap. Co. Line		114.4	435,3/4.3			

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Lakewood Gulch

Name	Type of Facility	Location		Average Flow		Pertinent Operations & Pollutants affecting Water Quality
		RM	Ry	MGD	CMS	
South Lakewood Waste Water Treatment Plant	Sewage	31.7	513.2	1.0	.079	(BOD_5, solids)

TABLE 7

Discharges of Record In South Platte River Basin as of 1973

Discharges to South Platte River - Main Stem

Name	Type of Facility	Location RM	Location RK	Average Flow m^3/s	Average Flow cfs	Pertinent Operations & Pollutants affecting Water Quality
Gates Rubber Co. (Mississippi Avenue)	Mfg. rubber products	327.5 325.3*	514.3 518.8	.088 1.7	3.1 .073	(BOD_5, solids, TKN, Heavy Metals)
Roberts Food		319	513.8	5.3×10^{-3}	.19	(TDS, pH)
Public Service Company (Val Plant)	Power Gen.-gas, oil coal	318	511.9	55.	1.9	(cooling, ion exchange (BOD_5, solids, Temp.)
Ellis Foods see Lakewood gulch see Cherry Creek enters @ 317.7 WQS - 70th St. Bridge	Food Processing, Canning	318 317.7 317.3	511.8 510.2	9.9×10^{-2}	3.5	(cooling water, Temp.)
City Ice Company		317	510.1	.4	14.	(Salts)
Burlington Northern RR	Fueling-car washing	316	508.3	0.11 est.	3.8 est.	(overflow BOD_5)
Safeway Stores		315	506.3	2.7×10^{-3}	.095	(Salts)
Denver Northside waste water Treatment Plant see Rock Mtn. Dairy enters @ 314.3 WQS - Franklin St. Bridge	Sewage	314.6 314.0	505.0 505.1			(from Sewer collects from Seepage RM 314.6

TABLE 7B

Discharges of Record In The South Platte River Basin as of 1973

Discharges to South Platte River - Cherry Creek Enters at 317.7 on South Platte

Name	Type of Facility	Location RM	Location BY	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
Glendale Sanitation District	Sewage	317.7/5	511.3/8.0	0.3	13.2×10^{-3}	
WQS - at mouth of Cherry Creek		317.7/0.1	511.3/0.2			

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Rocky Mountain Ditch enters @ 314.4

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
GAF	Manufacturing	$314.38/_{1.4}$	$505.93/_{2.2}$	0.027	1.18×10^{-3}	(pH, Solids)

TABLE 7L

Discharges of Record In the South Platte River Basin as of 1973

Discharges to South Platte River - Main Stem

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
Denver Rendering		313	503.7	0.86	.038	(BOD_5, solids)
National By-Products		313	503.7	0.18	$7.9X10^{-3}$	Cooling
Public Service Co. (Cherokee Station)	Power Gen., Coal	312.5	502.9	6.5	.285	(solids, pH)
Metro Denver Waste Water Treatment Plant (also discharges to Burlington Ditch) see Sand Creek enters @ 312.1 see Clear Creek enters @ 311.1	Sewage	312.2	502.4	116.0	5.09	(BOD_5, solids)
South Adams Waste Water Treatment Plant WQS - Henderson - Bridge to Adams Co. Fairgrounds	Sewage	306.7 301.7	493.6 485.5	1.8	.079	(BOD_5, solids)
Stokely Van Camp	Food Processing, Canning	296	476.4	0.063	$2.76X10^{-3}$	(Temp.)
Brighton Waste Water Treatment Plant	Sewage	295.8	476.0	1.3	.057	(BOD_5, solids)
Great Western Sugar - Brighton	Sugar Beet Processing	295.6	475.7	2.5	.110	Condenser + Irrig. Return Flow (BOD_5, nutrients) Bacteriological

TABLE 7F

Dischargers of Record on South Platte River Basin as of 1973

Dischargers to South Platte River - Sand Creek (enters South Platte - 335.1)

Name	Type of Facility	Location RM	Location RD	Average Flow MGD	Average Flow CFS	Pertinent Operations & Pollutants affecting Water Quality
Buckley Air National Guard Waste Water Treatment Plant	Sewage and Maintenance	312.1	500.3 14.7	.104	1.45x10⁻¹	Discharged to Toll Gate Creek
Fitzsimons Hospital Waste Water Treatment Plant	Hospital Sewage	311.7	500.3 8.9	.3	4.6x10⁻¹	Can be discharged to Toll Gate Creek also for irrigation
Stapleton International Airport City and County of Denver	Maintenance	311.1	502.3			Runoff of stormwater & ind. wastes possible
Refinery Corp.	Refinery	312.1 [1]	502.3	.344	5.3x10⁻¹	NO_3, Salts, N
Continental Oil	Refinery	312.1?	502.3	0.46	29.3x10⁻¹	NO_3, Salts, N 1/2 to Sand Creek via Burl. Ditch
Lester Jones Sand and Gravel	Aggregate	312.1?	500.3?			Washing

1/ Discharged to Burlington Ditch with [illegible] overflow to Sand Creek

TABLE 7B

Discharges of Record in the South Platte River Basin as of 1973

Discharges to South Platte River - Clear Creek, Entire South Platte @ 311.1

Name	Type of Facility	Location RM	Location Mi	Average Flow MGD	Average Flow CFS	Pertinent Operations & Pollutants affecting Water Quality
Loveland Ski Basin	Recreation (Sewage)					
Mountain Aggregate		311.1/ 4+	500.6/ 7.4	0.2	8.76×10^{-3}	
American Metals Climax - Urad		311.1/ 4+	500.6/ 79.3	.43	.067	(Solids)
Georgetown Waste Water Treatment Plant	Sewage					
Idaho Springs Waste Water Treatment Plant	Sewage	311.1/ 22.7	500.6/ 44.3	0.3	.013	(BOD5, Bacteriological)
Golden Water Treatment Plant	Domestic water	311.1/ 16	500.6/ 30.6	0.59	25.9×10^{-3}	
WQS - Upstream of Golden		311.1/ 17.9	500.6/ 28.8			
Adolph Coors Company	Brewery, Ceramics, Sewage, Plating	311.1/ 16	500.6/ 30.0	23.0	1.01	(BOD5, Solids, Temp.) Cooling
Wheat Ridge Waste Water Treatment Plant	Sewage	311.1/ 7.7	500.6/ 12.4	2.1	.092	(BOD5, solids, Bact.)
Suburban Sand and Gravel		311.1/ 7.5	500.6/ 12.5	0.20	.009	(Solids)
Clear Creek Valley Waste Water Treatment Plant	Sewage and Sigman Meat Co. (0.36 mgd)	311.1/ 7.0	500.6/ 11.3	0.6	21.9×10^{-3}	(BOD5, solids)
Arvada Waste Water Treatment Plant	Sewage	311.1/ 6.7	500.6/ 10.4	1.1	.044	(BOD5, solids)
Cotter Corporation (Schwartzwalder Mine)	Mining					Discharges to Ralston Creek
Western Paving		311.1/ 3.8	500.6/ 6.1	0.086	3.73×10^{-3}	
Baker Metro Water Treatment Plant	Domestic water	311.1/ 4.0	500.6/ 6.2	0.084	3.69×10^{-3}	
Baker Waste Water Treatment Plant	Sewage	311.1/ 3.4	500.6/ 5.5	1.0	.044	(BOD5, solids)
Western Paving		311.1/ 2.5	500.6/ 4.0	0.1	4.39×10^{-3}	
Peter Kiewit		311.1/ 2.0	500.6/ 3.2	0.03	1.3×10^{-3}	
WQS - Near Mouth		311./ 0.3	500.6/ 0.5			

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Big Dry Creek enters South Platte @ 288.6

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting water quality
(U.S. AEC) Dow Chemical Rocky Flats	Nuclear Materials Manufacturing	288.6/30	464.4/ 48.3	0.31	13.6×10^{-3}	To Great Western Reservoir
Broomfield Waste Water Treatment Plant	Sewage	288.6/20	464.4/ 32.2	0.8	.035	
Western Electric	Manufacturing	288.6/17	464.4/ 27.4	0.13	5.7×10^{-3}	Cooling (TDS)
Westminster Waste Water Treatment Plant	Sewage			0		

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Main Stem

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & & Contaminent Affecting Standards
see Big Dry Creek enters at 288.6						
Ft. Lupton Waste Water Treatment Plant	Sewage	287.6	462.8	0.8	.035	(Bacteria, Solids)
Platteville Waste Water Treatment Plant	Sewage	276	444 2	0.1	$4.39X10^{-3}$	(Bacteria)
La Salle Waste Water Treatment Plant	Sewage	273	439.3	0.1	$4.39X10^{-3}$	
see St. Vrain Creek enters at 270.0		270.0	434.5			
see Big Thompson River enters at 260.4		260.4	419.1			
see Cache La Poudre River enters at 249.0		249.0	400.7			
WQS - Near Kersey		46.5	396.7			
Crow Creek (Intermittant) discharges collected in vicinty of Cheyenne, Wyo.		241.7	389.0			
Great Western Sugar - Ft.Morgan	Sugar Beet Processing	196.2	315.7	10.8	.474	Condenser water (BOD_5, Solids, Nutrients, Temp.)
Ft. Morgan Waste Water Treatment Plant	Sewage	195.2	314.1	2.6	.114	(BOD_5, Solids, Bacteria)
Brush Waste Water Treatment Plant WQS - At Balzac	Sewage	185.6 174.0	298.7 280.0	1.1	.048	(BOD_5, Solids, Bacteria)
Terra Resources		169	272.0	0.022	$.96X10^{-3}$	
Great Western Sugar (Sterling)	Sugar Beet Processing	150.4	242.0	6.8	.298	Treated Process Water (BOD_5, Solids, N, Temp., Bacteria)
Sterling Waste Water Treatment Plant	Sewage	148.6	239.1	2.5	.110	(BOD_5, Solids, Bacteria)
Platte Valley Rendering	Meat By-product Processing	150	241.4	0.04	$1.75X10^{-3}$	(BOD_5, Solids, O&G)

TABLE 7P

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Dry Creek enters Boulder Creek @ 14.8

Name	Type of Facility	Location		Average Flow		Pertinent Operations & Pollutants affecting water quality
		LM	RK	MGD	CMS	
Beech Aircraft	Mfg. Plating, Rocket Testing	270/14.8/15	434.5/23.9/24.1	0.003	1.32×10^{-4}	(Cr)
Boulder Water Treatment Plant	Domestic Water	270/14.8/16	434.5/23.9/16.1	3.15	.139	

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Coal Creek enters Boulder Creek @ 7.9

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting water quality
Ideal Industries	Cement	270/17.6/ 7.9/19	434.5/28.3/ 12.7/30.6	0.064	2.8×10^{-3}	
Louisville Wastewater Treatment Plant	Sewage	270/17.6/ 7.9/9	434.5/28/3/ 12.7/14.5	0.2	8.78×10^{-3}	(BOD_5, solids, Bacteria)
Lafayette Wastewater Treatment Plant	Sewage	270/17.6/ 7.9/5	434.5/28.3/ 12.7/8.0	0.1	4.39×10^{-3}	(BOD_5, Solids, Bacteria)
Erie Wastewater Treatment Plant	Sewage	270/17.6/ 7.9/1	434.5/28.3/ 12.7/1.6	0.1	4.39×10^{-3}	(BOD_5, Solids, Bacteria)

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Boulder Creek enters St. Vrain Creek @ 17.4

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting water quality
Boulder Water Treatment Plant	Domestic Water	270/17.4/ 10	434.5/28.0/ 6.1	1.53	.067	
Flatiron Premix		270/17.4/ 22	434.5/28.0/ 35.4	3.2	.140	(BOD_5, Solids)
Boulder Wastewater Treatment Plant (Pearl Street)	Sewage	270/17.4/ 21.3	434.5/28.0/ 34.3	4.	.176	(BOD_5, Solids)
Public Service Company (Boulder)	Power Gen - Coal	270/17.4/	434.5/28.0/	9.9	.435	(BOD_5, Solids) Discharge to Lakes
C & M Sand and Gravel		270/17.4/ 20	434.5/28.0/ 32.2	0.8	.035	(Solids)
Boulder Waste Water Treatment Plant (75th Street)	Sewage	270/17.4/ 17.8	434.5/28.0/ 28.6	7.8	.342	(BOD_5, Solids)
See Dry Creek enters @ 14.8 See Coal Creek enters @ 7.9 WQS - Boulder-Weld Co Line		270./17.4/ 7.0	434.5/28.0/ 11.3			

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Saint Vrain Creek enters South Platte @ 270

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
Lyons Waste Water Treatment Plant	Sewage	270/39	434.5/62.8	0.1	4.39×10^{-3}	(BOD_5, Bacteria)
Longmont Water Treatment Plant	Domestic Water	270/35	434.5/56.3	1.63	7.16×10^{-2}	
Golden Gravel		270/25	434.5/40.2	0.004	1.75×10^{-4}	
Longmont Waste Water Treatment Plant	Sewage	270/23	434.5/37.0	3.7	.162	(BOD_5, Solids, Bacteria)
Gould Filters		270/22	434.5/35.4	0.038	1.67×10^{-3}	
Great Western Sugar Co. - Longmont	Sugar Beet Proc.	270/21	434.5/33.8	7.0	.307	Condenser Water (BOD_5, Solids, Temp, Bact.)
WQS - Weld - Boulder County Line		270/20.6	434.5/33.5			
see Boulder Creek enters @ 17.4		270/17.4	434.5/28.0			
WQS - Downstream of Longmont		270/17.2	434.5/27.7			
WQS - Near Mouth		270/1.3	434.5/2.1			
Public Service Co. (Ft. St. Vrain)	Power Gen.(nuclear)	270/1.0	434.5/1.6	3.0	.132	(BOD_5, Solids, Temp)

TABLE 7E

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Big Thompson River enters South Platte @ 260.4

Name	Type of Facility	Location MM	Location RM	Average Flow MGD	Average Flow CMS	Pertinent Operations & Contaminent Affecting Standards
Controlled Stream Flow						
Fish Hatchery #02, Colo. F&G, Estes Park	Fish Rearing	260.4/60.5	419.1/97.4	1.8	.079	(BOD_5, Solids, N)
Federal Facilities U.S. Rocky Mountain National Park	Sewage	260.4/60	419.1/96.6	0.024	1.05×10^{-3}	(BOD_5, Solids)
Estes Park Waste Water Treatment Plant	Sewage	260.4/54.5	419.1/87.7	0.9	3.95×10^{-2}	(BOD_5, Solids)
Fish Hatchery, Colo. F&G, Drake	Fish Rearing	260.4/42	419.1/67.6	3.9	.171	(BOD_5, Solids, N)
Flatiron Paving (Loveland)		260.4/	419.1/	3.0	.132	(Solids)
Loveland Packing Co.	Beef & Pork Processing	260.4/25.5	419.1/41.0	0.05	2.19×10^{-3}	Process Water (BOD_5)
Flatiron Sand & Gravel (Loveland)		260.4/	419.1/	2.5	.110	(Solids)
Loveland Water Treatment Plant	Domestic Water	260.4/	419.1/	0.15	6.58×10^{-3}	
Loveland Waste Water Treatment Plant	Sewage	260.4/24.5	419.1/39.4	2.7	.118	(BOD_5, Solids, Bact.)
Great Western Sugar (Loveland)	Sugar Beet Process	260.4/22.5	419.1/36.2	8.2	.360	Treated Process Water (BOD_5, Solids)
Greeley Water Treatment Plant see Little Thompson River enters @ 7.0	Domestic Water	260.4/ 260.4/7.0	419.1/ 419.1/11.3	0.12	5.27×10^{-3}	
WQS - Near Mouth		260.4/0.9	419.1/1.4			
Floyd Hoag Sand and Gravel	Aggregate					Washing

TABLE 7B

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Eaton Draw enters Cache La Poudre River @ 6.9

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
Great Western Sugar (Eaton)	Sugar Beet Processing	249/6.9/7. (3 discharges)	400.7/11.1/ 11.3	2.6	.114	Condenser, Scruber boilers (BOD_5, Solids, N, Bacteria)
Eaton Wastewater Treatment Plant	Sewage	249/6.9/6.5	400.7/11.1/ 10.5	0.2	8.78×10^{-3}	(BOD_5, Bacteria)

TABLE 7b

Discharges of Record in South Platte River Basin as of 1973

Discharges to South Platte River - Cache La Poudre River enters South Platte @ 249.0

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
Fish Hatchery - Austin (Lulu Fish) AUS - upstream Ft. Collins	Fish Rearing	244/74 244/66.3	400.7/119.1 400.7/90.6	7.4	.325	(BOD_5, Solids, Bacteria)
Fish Hatchery Belleview Colo. F&G	Fish Rearing	249/49	400.7/78.8	1.5	.066	(BOD_5, Solids, N, Bact.)
Fish Hatchery Belleview Colo. T&G	Fish Rearing	249/47	400.7/76.6	11.5	.505	(BOD_5, Solids, N, Bact.)
Poudre Fronts	Concrete	249/46	400.7/74.0	0.004	1.76×10^{-4}	
Hancmay Feedmills		249/46	400.7/74.0	0.00006	2.63×10^{-6}	pH
Greeley Water Treatment Plant (Boyd Lake-Poudre) (Belleview)	Domestic Water Domestic Water			.1 .6	4.4×10^{-3} 26.3×10^{-3}	
Ft. Collins Water Treatment Plant	Domestic water	249/46	400.7/74.0	0.7	.031	pH
Ft. Collins Light & Power	Power Gen.	249/46	400.7/74	0.31	.014	Temp. pH
Lone Star Steel		249/45	400.7/72.4	0.03	1.3×10^{-3}	(BOD_5, Solids, Bacteria)
Ft. Collins #1 Waste Water Treatment Plant	Sewage	249/44.1	400.7/71.0	3.9	.171	(BOD_5, Solids, Bacteria)
Ft. Collins #2 Waste Water Treatment Plant	Sewage	249/44.0	400.7/64.7	3.9	.171	(BOD_5, Solids, Bacteria)
Loveland Waste Water Treatment Plant	Sewage	249/39.2	400.7/63.1	0.3	.013	(BOD_5, Bacteria)
Terra Resources		249/35	400.7/56.3	0.009	3.95×10^{-4}	
Flatiron Paving		249/23	400.7/46.7	2.8	.123	(TDS)
Windsor Waste Water Treatment Plant	Sewage	249/23	400.7/37.0	0.15	6.58×10^{-3}	(BOD5)
Mountain Aggregate		249/11	400.7/19.1	0.20	1.3×10^{-2}	
Greeley Sand & Gravel		249/10	400.7/16.1	3.0	.132	
Flatiron Paving (Now Eaton Gravel Pit)		249/10	400.7/15.1	2.0	.088	(TDS)
West County Ln Ft Collins Sec	Dairy Food	249/2.4	400.7/11.0			(Bact.,BOD_5) lagoon seepage
Portion of Sanitary Landfill Co.	Meat & Lard Processing	249/0	400.7/4.0	0.0004	1.7×10^{-5}	Cooling & Washout Water-Inside Flow
Greeley Waste Water Treatment Plant	Sewage	248/6.3	400.7/6.0	7.0	.307	(BOD_5, Solids, Bacteria)
Great Western Sugar Co. (Greeley) W.D. - near Greeley	Sugar Beet Processing	248/4.0 248/2.4	400.7/7.0 400.7/4.7	7.0 (seasonal)	.307	(BOD_5, Solids, Nutrients Temp., Bacteria)

TABLE 7B

Discharge of Record in the South Platte River Basin as of 1973

Discharges to South Platte River - Main Stem

Name	Type of Facility	Location RM	Location RK	Average Flow MGD	Average Flow CMS	Pertinent Operations & Pollutants affecting Water Quality
Crook Waste Water Treatment Facility	Sewage	118	189.9	0.025	$1.10X10^{-3}$	(BOD_5, Solids)
Ovid Waste Water Treatment Facility	Sewage	95.0	152.9	0.025	$1.10X10^{-3}$	(BOD_5, Solids)
Great Western Sugar Company (Ovid)	Sugar Beet Processing	94.8	152.6	5.0	.220	Treated Process Water (BOD_5, Solids, Nutrients, Bacteria)
Julesburg Wastewater Treatment Plant	Sewage	89.6	144.2	0.2	$8.78x10^{-3}$	(BOD_5, Solids, Bacteria)
WQS - Near Julesburg		87.0	140.0			

TABLE 7C

Summary of Major* Industrial Discharges in the

South Platte River Basin as of 1973

Facility	Location RK	Receiving Stream	MGD	CMS
Public Service (Zuni)	511.8	South Platte	44	1.932
Public Service (Cherokee)	502.9	South Platte	6.5	0.285
Great Western - Brighton	475.7	South Platte	2.5	0.110
American Metals Climax - Urad	500.6/78.9	Clear Creek	8.93	0.392
Coors	500.6/30	Clear Creek	23.0	1.010
Great Western Ft. Morgan	315.7	South Platte	10.8	0.474
Great Western Sterling	242.0	South Platte	6.8	0.298
Great Western Longmont	434.5/33.5	St. Vrain	7.0	0.307
Public Service - Ft. St. Vrain	435.5/2.1	St. Vrain	3.0	0.132
Flatiron Premix	434.5/28.0/35.4	Boulder Creek	3.2	0.140
Public Service - Valmont	434.5/28.0/	Boulder Creek	9.9	0.434
Fish Hatchery	419.1/67.6	Big Thompson	3.9	0.171
Flatiron Paving	419.1/	Big Thompson	3.0	0.132
Flatiron Sand & Gravel	419.1/	Big Thompson	2.5	0.110
Great Western Loveland	419.1/36.2	Big Thompson	8.2	0.360
Great Western Johnstown	419.1/11.3/	Little Thompson	4.0	0.176
Fish Hatchery - Rustic	400.7/119.1	Cache La Poudre	7.4	0.325
Fish Hatchery - Belleview	400.7/78.8	Cache La Poudre	11.5	0.505
Flatiron Paving	400.7/46.7	Cache La Poudre	2.8	0.123
Greeley Sand & Gravel	400.7/16.1	Cache La Poudre	3.0	0.132
Flatiron Paving	400.7/16.1	Cache La Poudre	2.0	0.088
Great Western -(Greeley)	400.7/7.2	Cache La Poudre	7.5	0.329
Great Western -(Eaton)	400.7/11.1/11.3	Eaton Draw	2.6	0.114
Great Western -(Ovid)	152.6	South Platte	5.0	0.219
		Totals	179.03	7.859

* For the purposes of this table, major industrial discharges are those having discharge volumes equal to or greater than 0.09 cms or ~2 MGD.

most stream and discharge confluences must also be determined by short term surveys. Obviously, determinations of mixing zone dimensions will dictate station locations for the water quality surveillance system and until these dimensions are known, or are specified, locations must be set tentatively. Similarly, areas of nonpoint source discharges should be determined.

A network comprised of seven stations is herein proposed for the main stem of the South Platte River. An additional six stations are considered necessary to monitor the major tributary streams. Station locations and data to be gathered are presented in Table 8.

It must be emphasized that the thirteen stations are derived from the premise that they are long-term (>10 years) stations designed to show long-term trends and major violations of surface water quality standards. It might reasonably be expected that an equivalent number of additional stations would have to operate at other locations at any given time, where the purpose of the additional stations would be to evaluate or quantify such factors as the potential of Clear Creek as a fishery, water quality in the lake formed by Chatfield Dam, the source of wastes in Clear Creek, the mixing of discharges from sewage treatment plants and industrial facilities or the impact of Clear Creek on the quality of the South Platte River. Further, the network of stations proposed in Table 8 also assumes adequate monitoring of point source and non-point sources of water quality degradation

TABLE 8

PROPOSED WATER QUALITY SURVEILLANCE STATIONS FOR SOUTH PLATTE RIVER BASIN IN COLORADO

Station Description and Location	Flow	Field Measurements	DO	Color	Common Ions	Nutrients	Organics	Suspended Solids	Trace Elements	Microbiological	Biological	Fisheries	Radiological	Pesticides
South Platte River @ South Platte	1	2	2	2	2	2	2	2	5	2	5/6	6	5*	6
South Platte River @ Colorado 470	1	1	1	2	2	2	2	2	5	2	5/6	6	0	0
Bear Creek near Mouth	1	2	2	2	2	2	2	2	5	2	5/6	6	0	0
South Platte River @ Alameda Avenue	1	2	2	2	2	2	2	2	5	2	5/6	6	0	0
Cherry Creek near Mouth	1	2	2	2	2	2	2	2	5	2	5/6	6	0	0
South Platte River near Franklin St.	1	1	1	2	2	2	2	2	5	2	5/6	6	0	0
Clear Creek near Mouth	1	2	2	2	2	2	2	2	5	2	5/6	6	0	0
South Platte River near Henderson	1	1	1	2	2	2	2	2	4	2	5/6	6	0	6
St. Vrain Creek near Mouth	1	2	2	2	2	2	2	2	5	2	5/6	6	3**	6
Big Thompson River near Mouth	1	2	2	2	2	2	2	2	5	2	5/6	6	0	6
Cache La Poudre River near Mouth	1	2	2	2	2	2	2	2	5	2	5/6	6	0	6
South Platte River near Kersey	1	2	2	2	2	2	2	2	5	2	5/6	6	5*	6
South Platte River near Julesburg	1	1	1	2	2	2	2	2	5	2	5/6	6	0	6

Frequency of measurements indicted thus:
0: None
1: Continuous
2: Weekly
3: Monthly
4: Bi-monthly
5: Quarterly
6: Seasonal (High-Low Flow)

Description of Measurements:

Field Measurements: Spec. Cond., pH, Temp

Common Ions: Si, Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl

Nutrients: T-PO_4, O-PO_4, NO_3-N, NO_2-N, NH_3-N, TKN

Organics: BOD_5, COD, TOC

Trace Elements: B, F, Mn, Fe, Cu, Zn, Sr, Ba, Pb, Mo, Ag, Al, As, Hg, Se, Oil & Grease

Microbiological: Total Coliform, Fecal Coliform

Biological: Benthos, Periphyton, Bottom Sediment (Sampled quarterly first 2 yrs, then seasonal)

Fisheries: Fish, Biomass (Fish, Algal, Invertebrate)

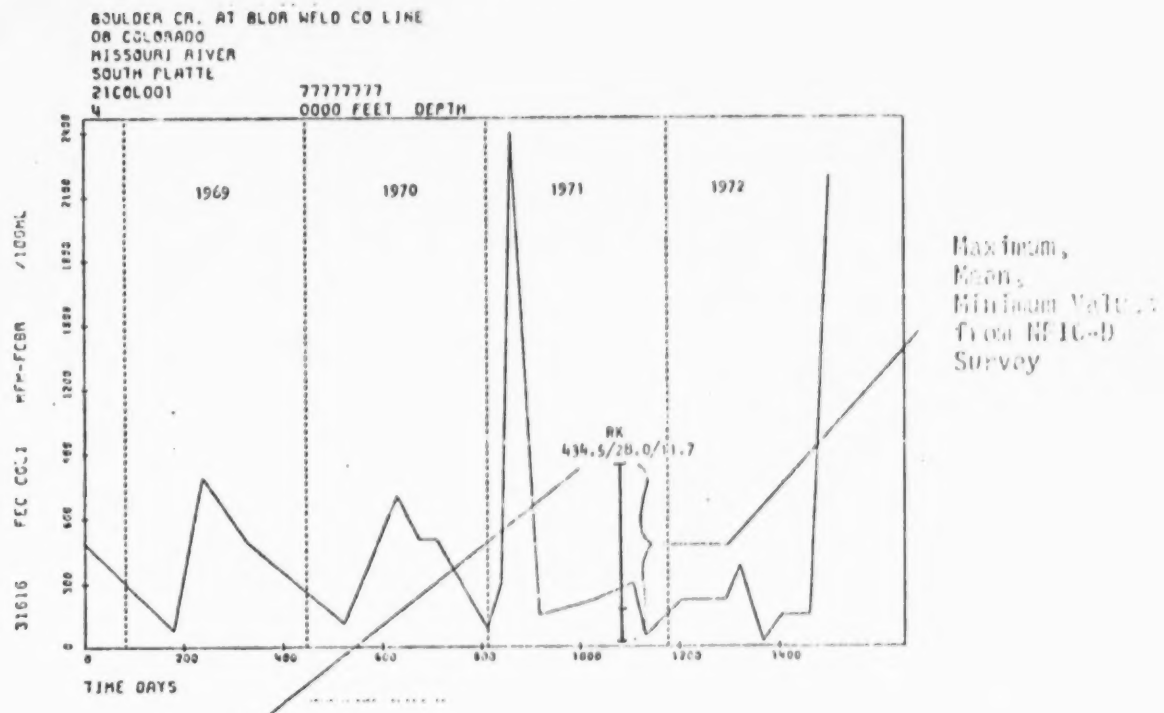
Radiological: * Natural Radionuclides, Tritium, Strontium - 90, Gamma Scan

** Tritium, Strontium - 90, Gamma Scan

APPENDIX A

Key For Appendices

Sampling Location
State in which sampling was conducted
Major drainage basin
Major drainage sub basin



Maximum,
Mean,
Minimum Values
from NFIC-D
Survey

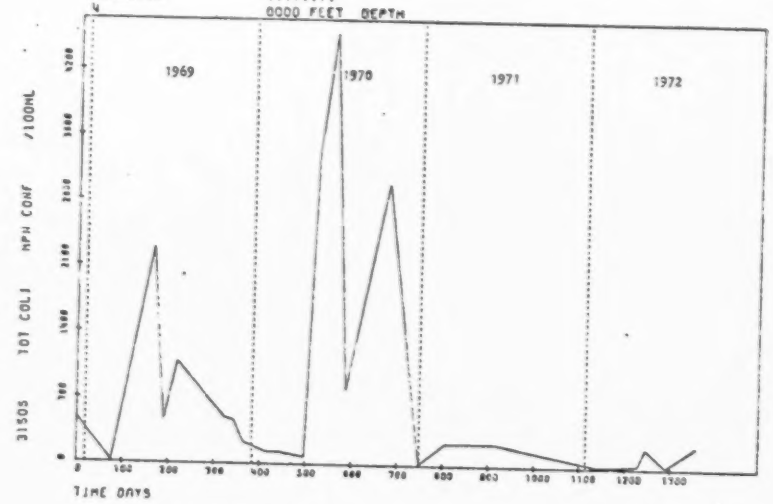
River kilometers (main stem and tributaries) which denote sampling locations occupied by the National Field Investigations Center - Denver (NFIC-D) survey during the Fall of 1971. If no "RK" value is shown, the NFIC-D samples were collected at the same location as the state and county samples.

If no NFIC-D data is shown on graph (a dark, vertical line above the September or December, 1971 points on the horizontal scale) either no sample was collected by NFIC-D or else the sample value exceeded the upper limit imposed on the vertical scale and could not be shown.

APPENDIX A - 1

Computer Plots of Total Coliform Concentrations vs. Time at Long Term Water Quality Monitoring Stations in the South Platte River

SOUTH PLATTE AT SOUTH PLATTE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH



SOUTH PLATTE ABOVE LITTLETON (Highway 470)
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
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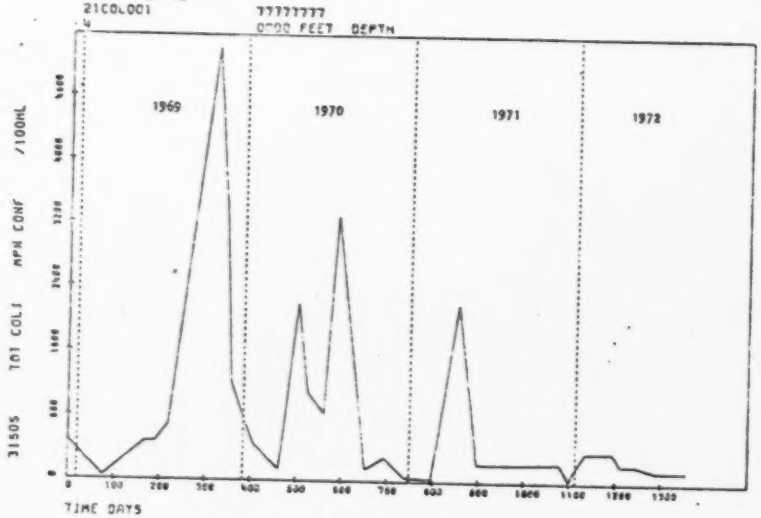
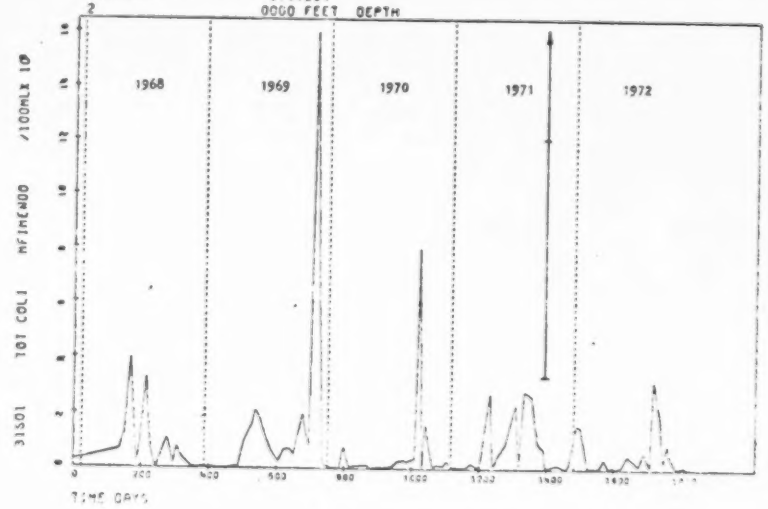
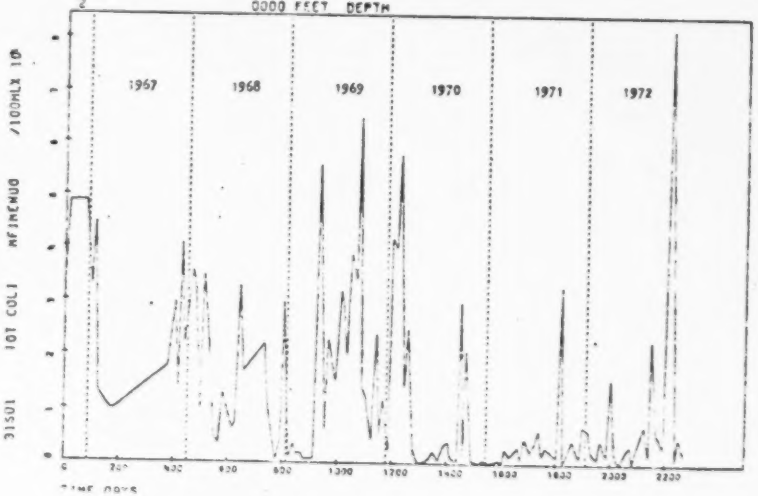
4 0000 FEET DEPTH

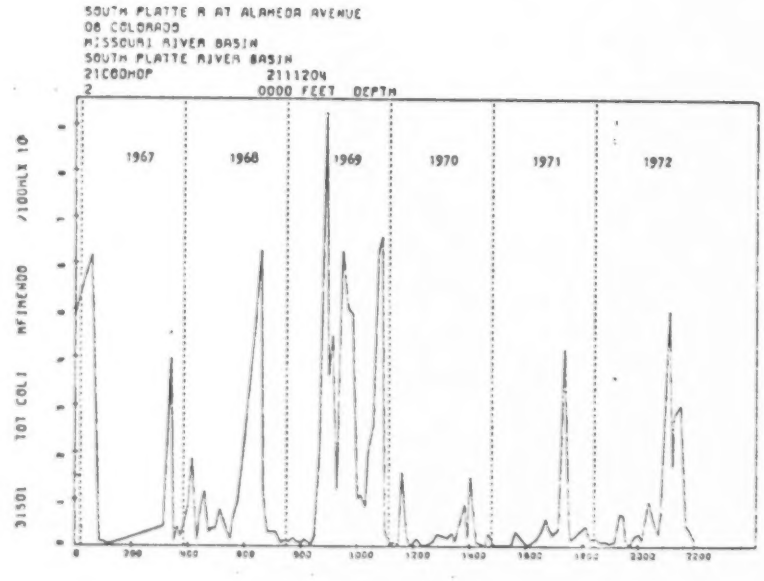


SOUTH PLATTE R AT BOWLES AVENUE
08 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C30HOP 2111204
2 0000 FEET DEPTH



SOUTH PLATTE R AT DARTMOUTH AVE
08 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HOP 2111204
2 0000 FEET DEPTH




SOUTH PLATTE R AT ALAMEDA AVENUE
08 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HOP 2111204
2 0000 FEET DEPTH
31501 TOT COLI MFIMENDO /100ML 10
1967
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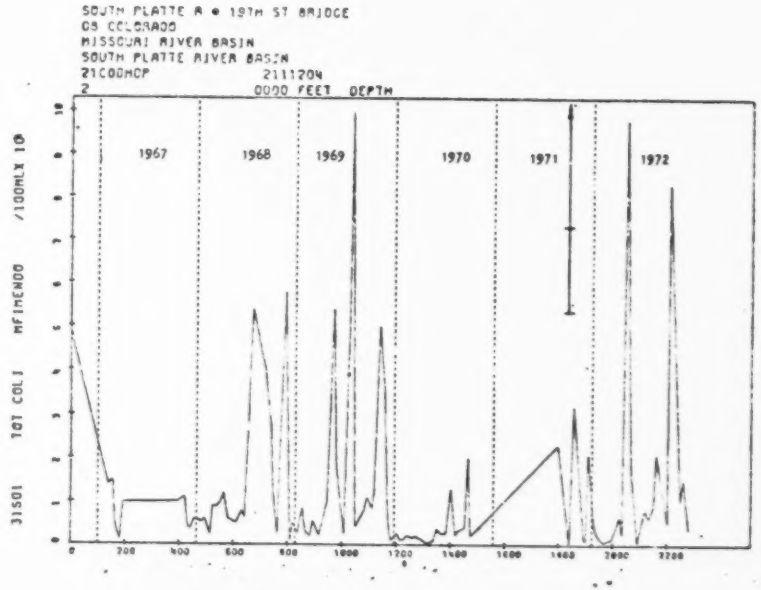
SOUTH PLATTE R @ 19TH ST BRIDGE
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MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
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31501 TOT COLI MFIMENDO /100ML 10
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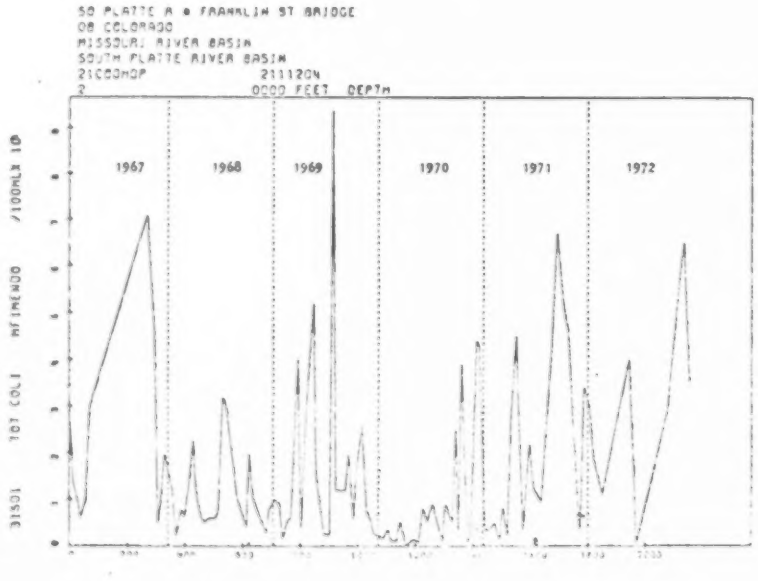
SO PLATTE R @ FRANKLIN ST BRIDGE
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MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
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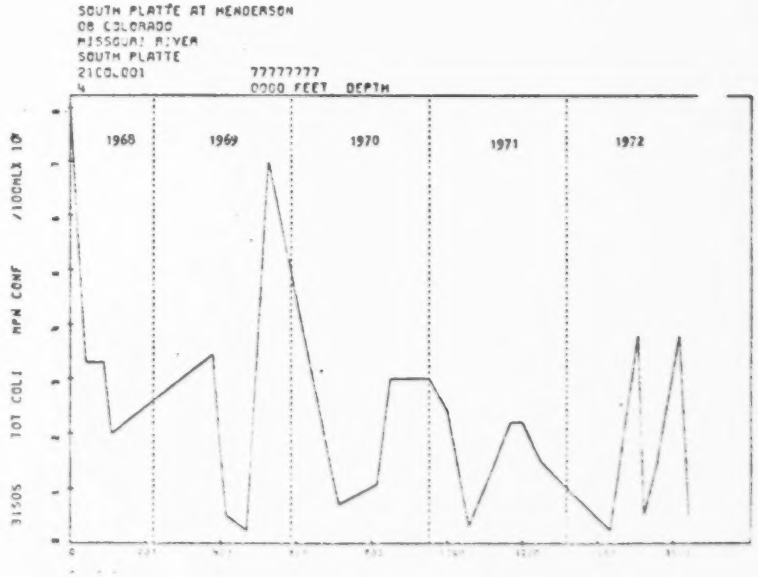
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MISSOURI RIVER
SOUTH PLATTE
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4 0000 FEET DEPTH
31505 TOT COLI MPN CONF /100ML 10
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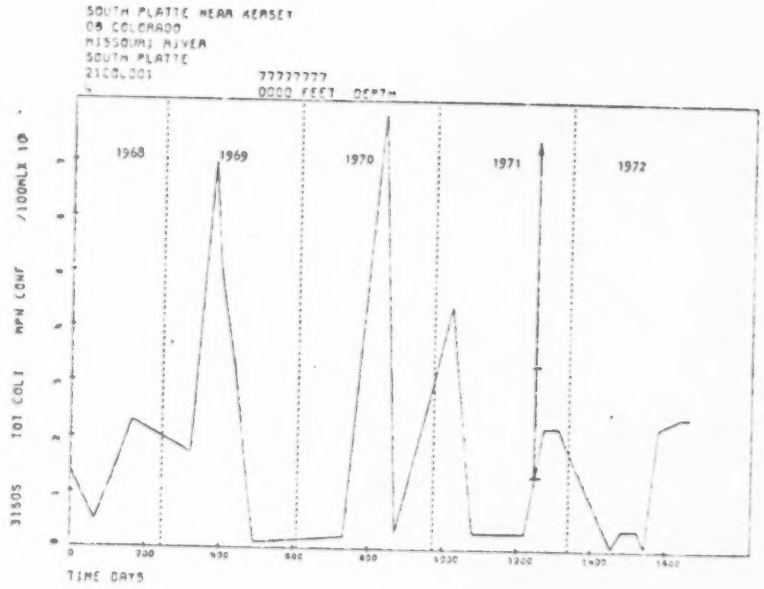
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CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
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77777777
0000 FEET DEPTH
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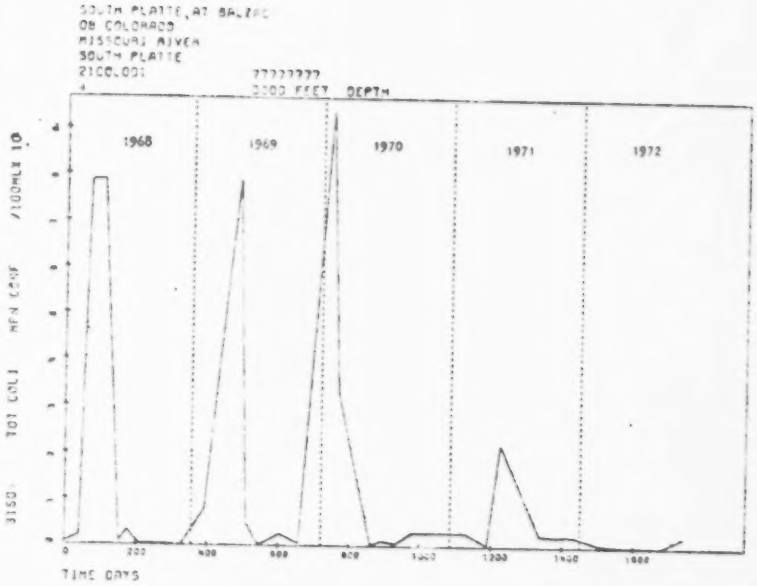
1972
TOT COLI MPN CONF /100ML X 10
TIME DAYS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MISSOURI RIVER
SOUTH PLATTE
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0000 FEET DEPTH
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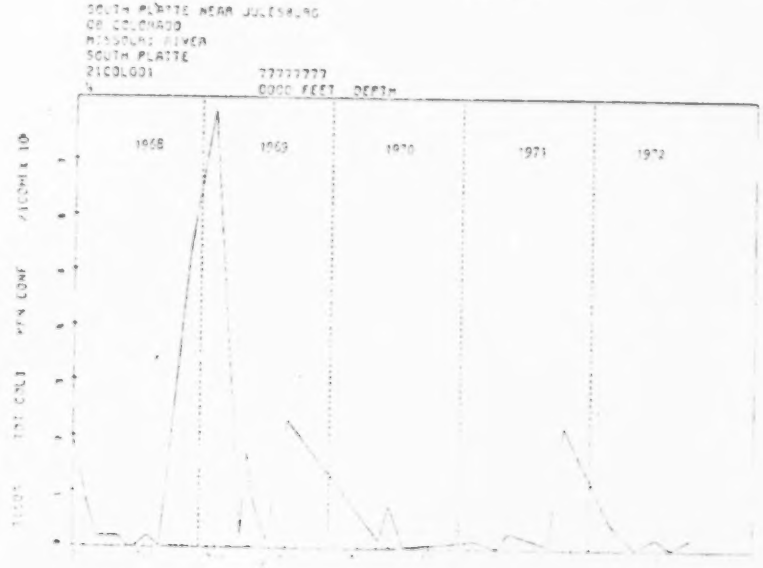
1972
TOT COLI MPN CONF /100ML X 10
TIME DAYS


SOUTH PLATTE NEAR JULESBURG
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
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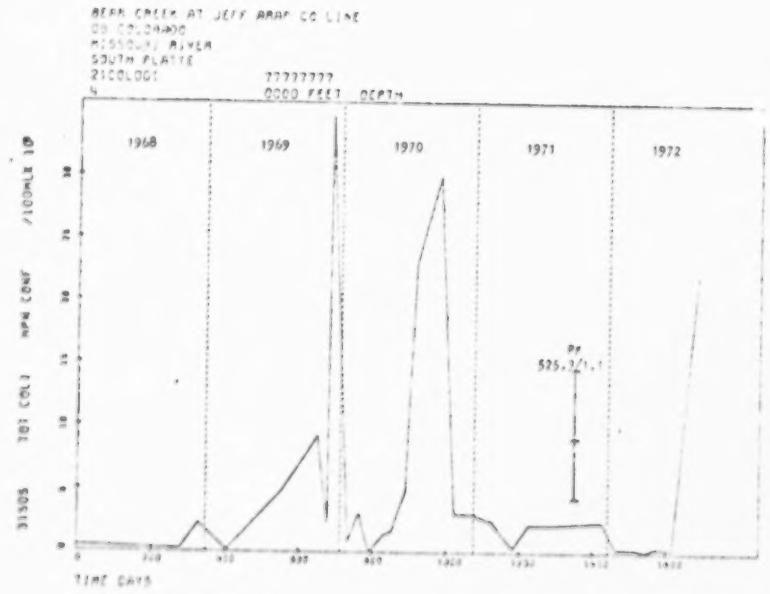
TOT COLI MPN CONF /100ML X 10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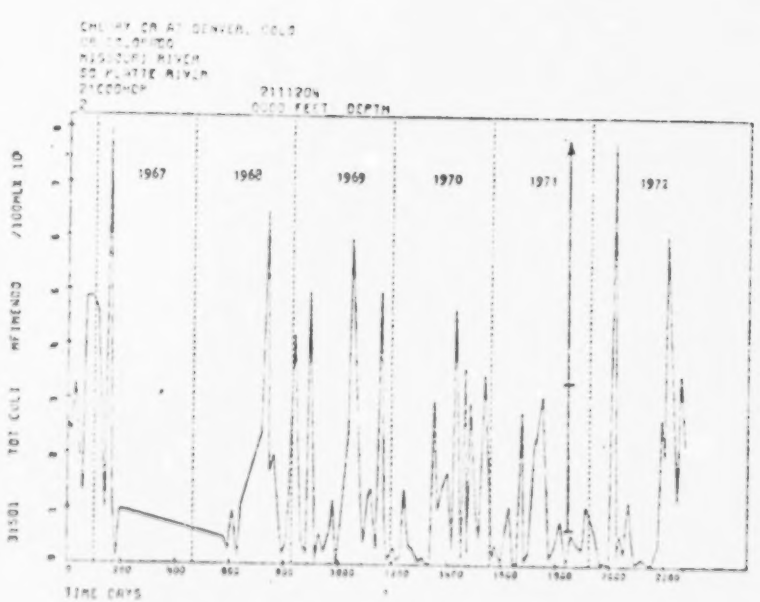
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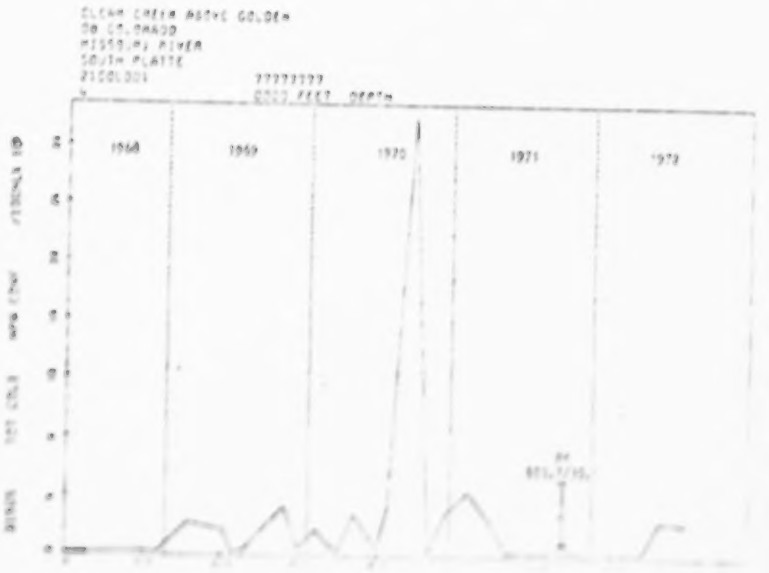
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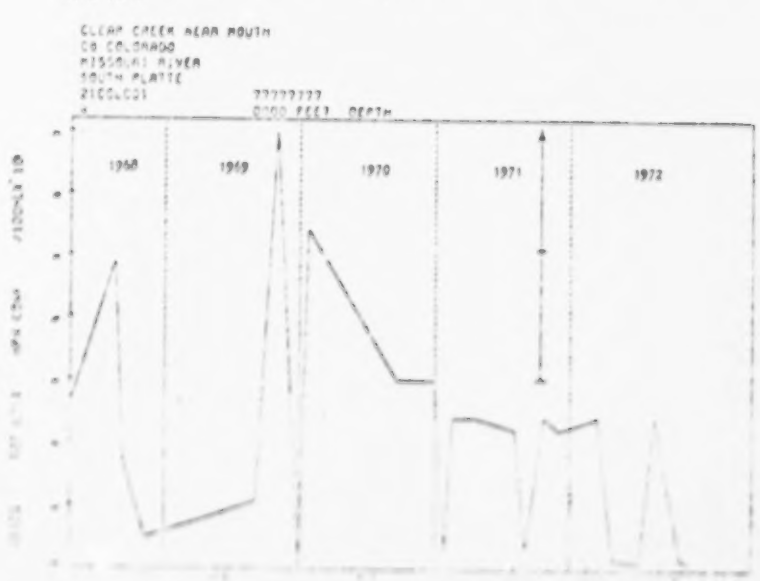
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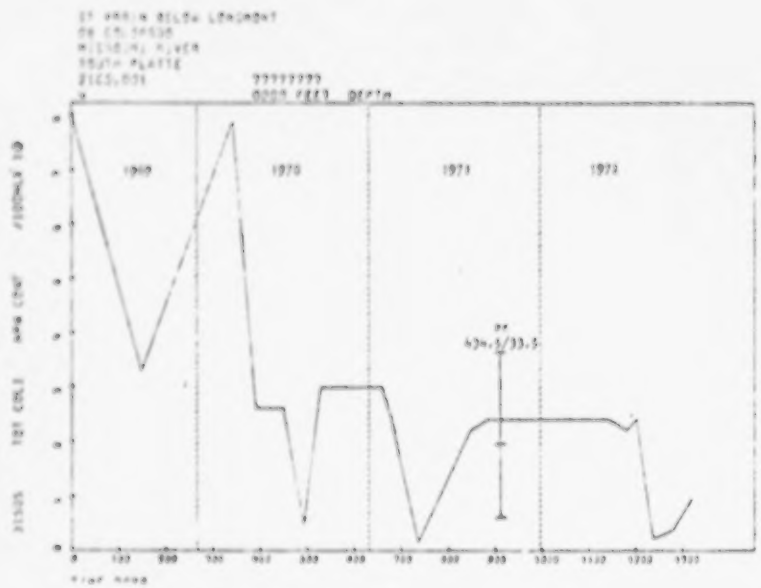
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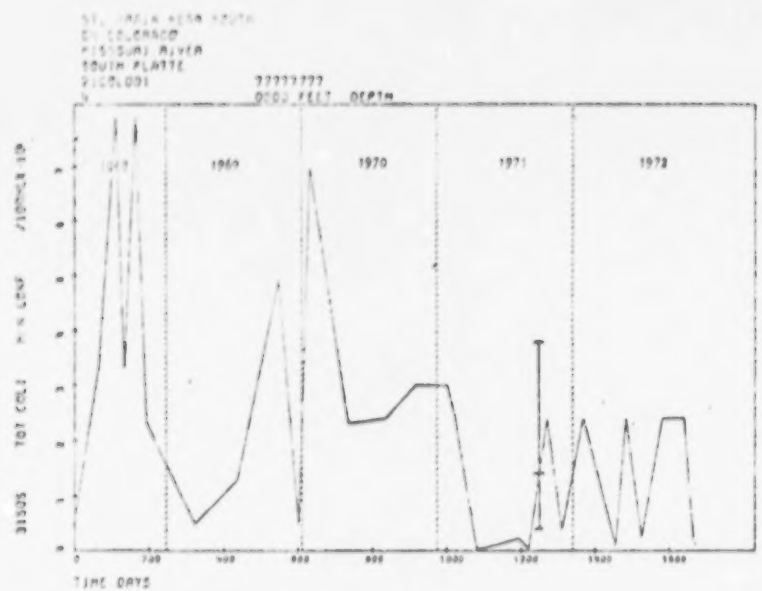
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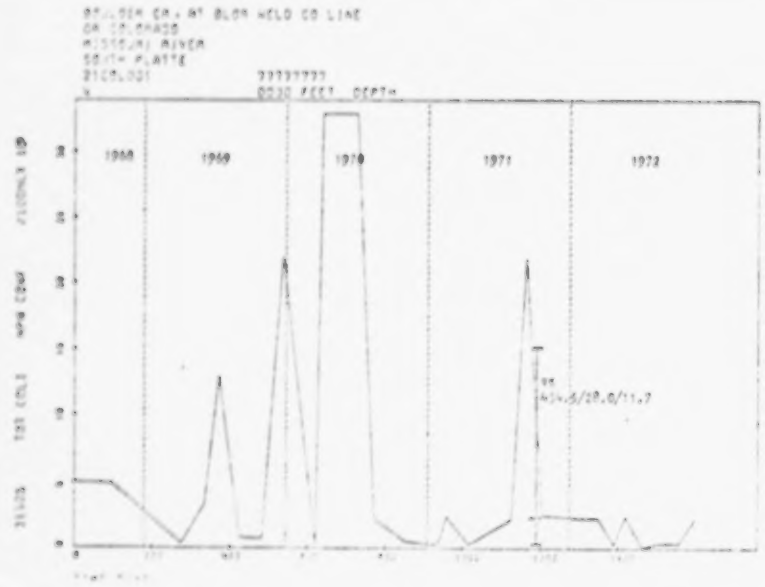
TIME DAYS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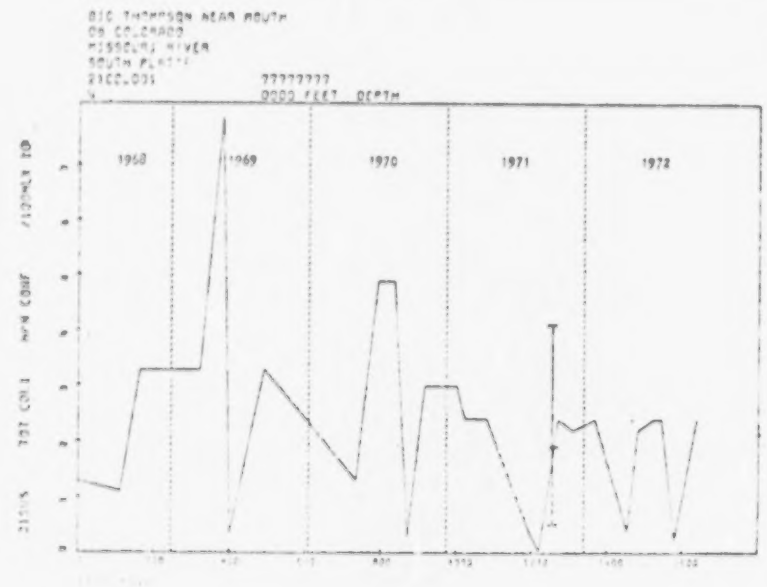
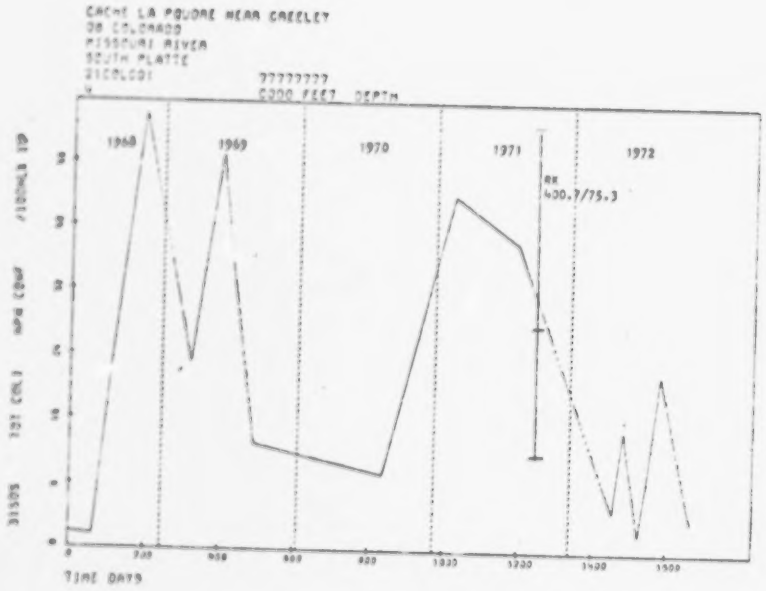
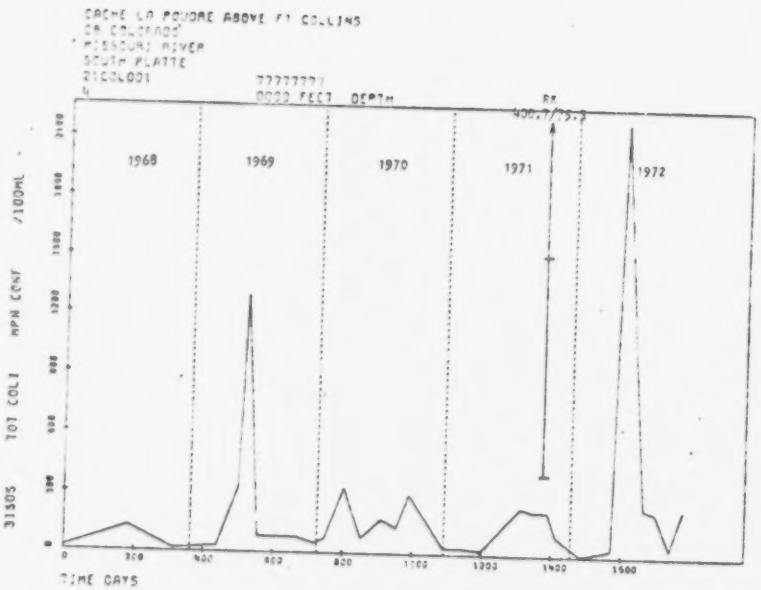
1971
1972

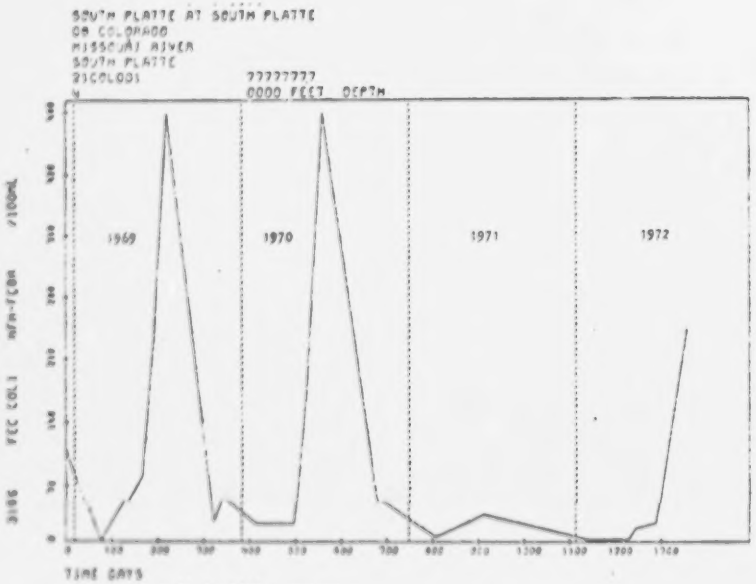

1968
1969
1970
1971
1972

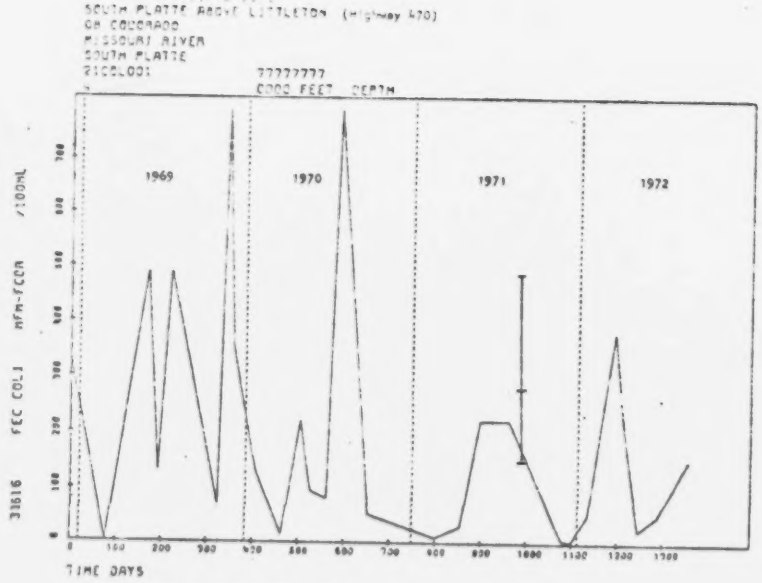

CACHE LA POUDRE NEAR GREELEY
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
RICOLOGI
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
RR
430.7/75.3
TIME DAYS

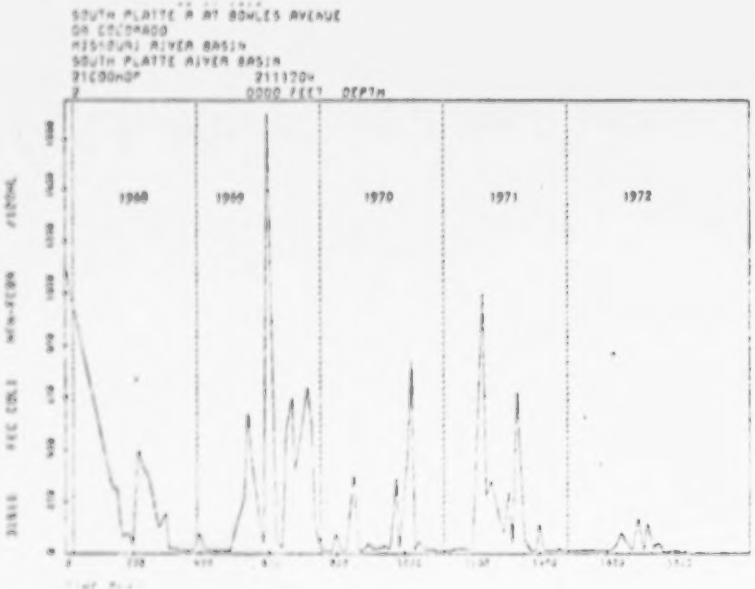

CACHE LA POUDRE ABOVE FT COLLINS
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
RICOLOGI
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
TIME DAYS

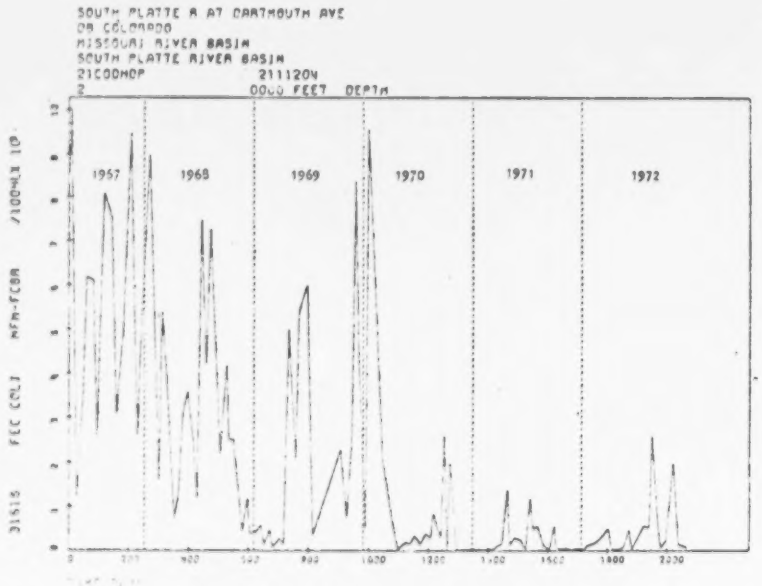
APPENDIX A - 2

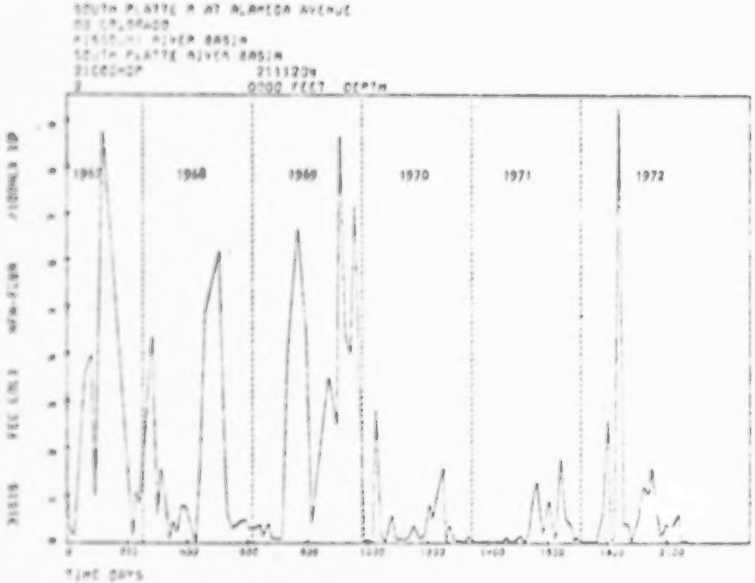
Computer Plots of Fecal Coliform Concentrations vs. Time at Long Term Water Quality Monitoring Stations in the South Platte River

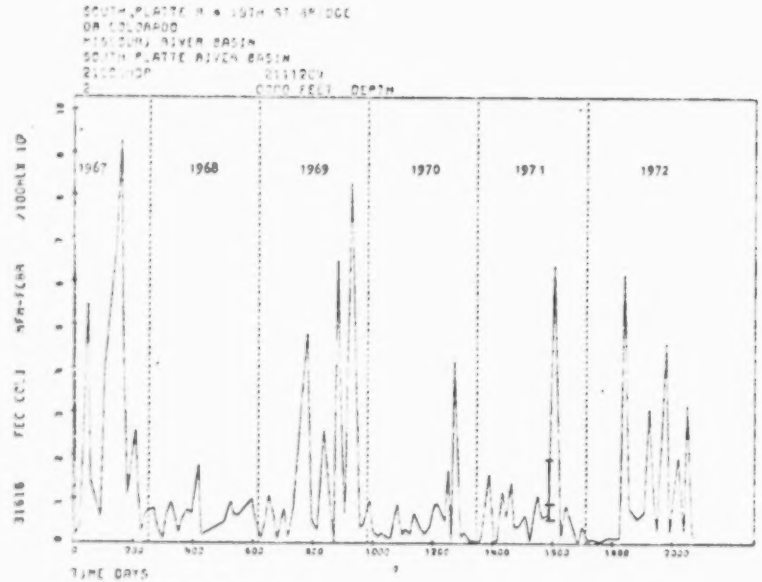

SOUTH PLATTE AT SOUTH PLATTE
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLOSI 77777777
0000 FEET DEPTH
31616 FEC COLI MFM-FCBR /100ML
1969
1970
1971
1972
TIME DAYS

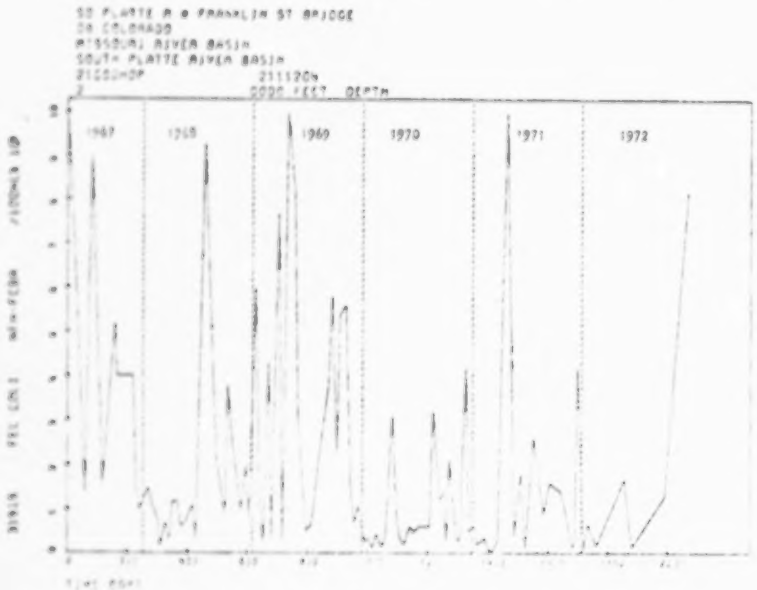

SOUTH PLATTE ABOVE LITTLETON (Highway 470)
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLOSI 77777777
0000 FEET DEPTH
31616 FEC COLI MFM-FCBR /100ML
1969
1970
1971
1972
TIME DAYS

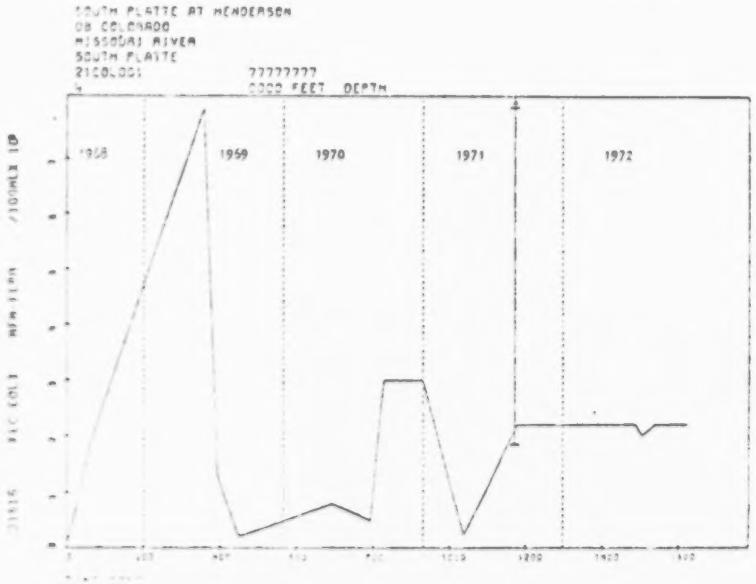

SOUTH PLATTE R AT BOWLES AVENUE
CO COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21COOMDP 211120W
0000 FEET DEPTH
31616 FEC COLI MFM-FCBR /100ML
1968
1969
1970
1971
1972

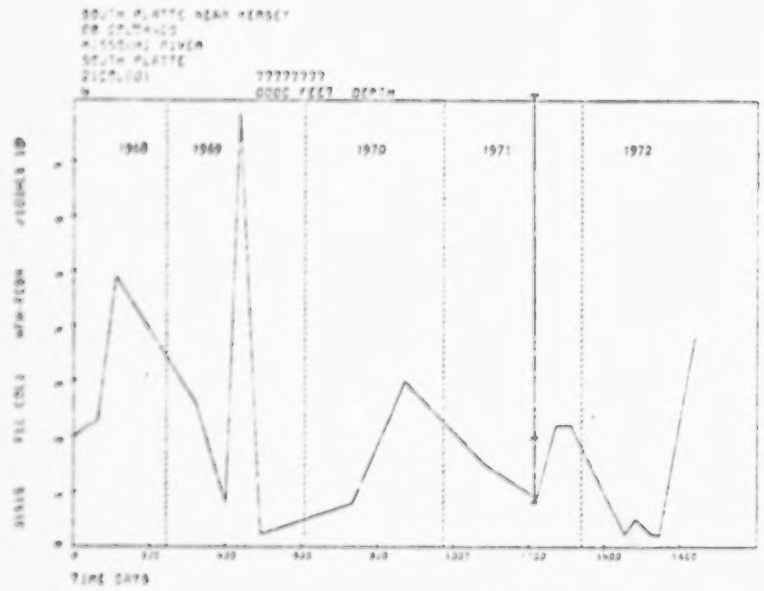

SOUTH PLATTE R AT DARTMOUTH AVE
CO COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21COOMDP 211120W
0000 FEET DEPTH
31616 FEC COLI MFM-FCBR /100ML
1967
1968
1969
1970
1971
1972

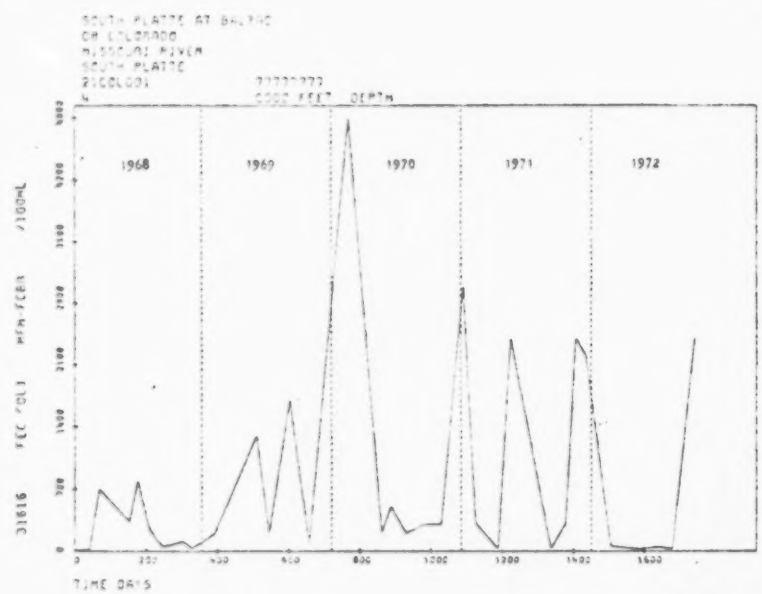

1967
1968
1969
1970
1971
1972
TIME DAYS

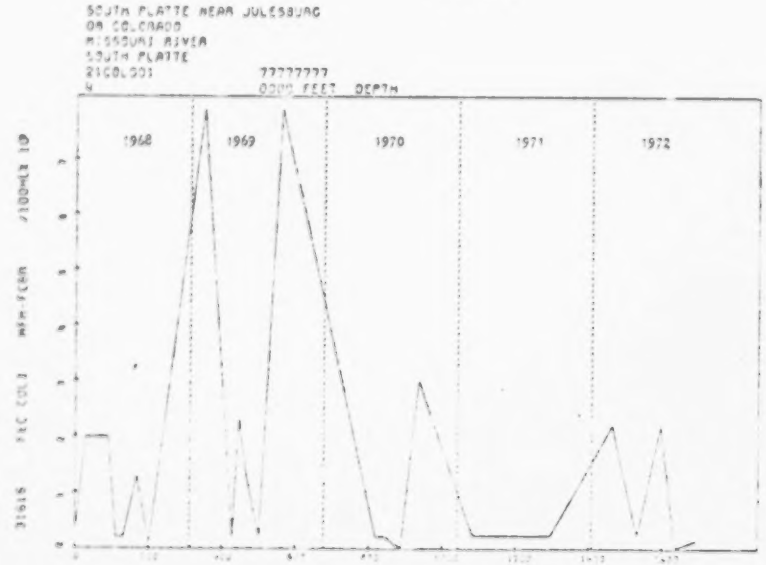

1967
1968
1969
1970
1971
1972
TIME DAYS

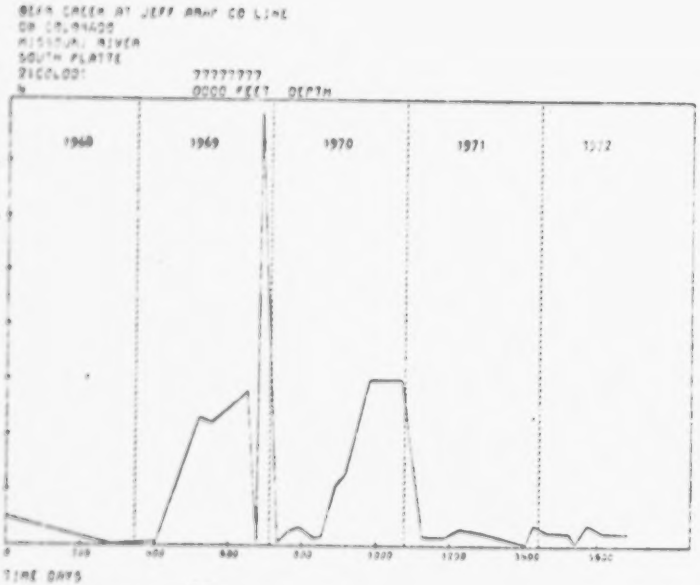

1967
1968
1969
1970
1971
1972

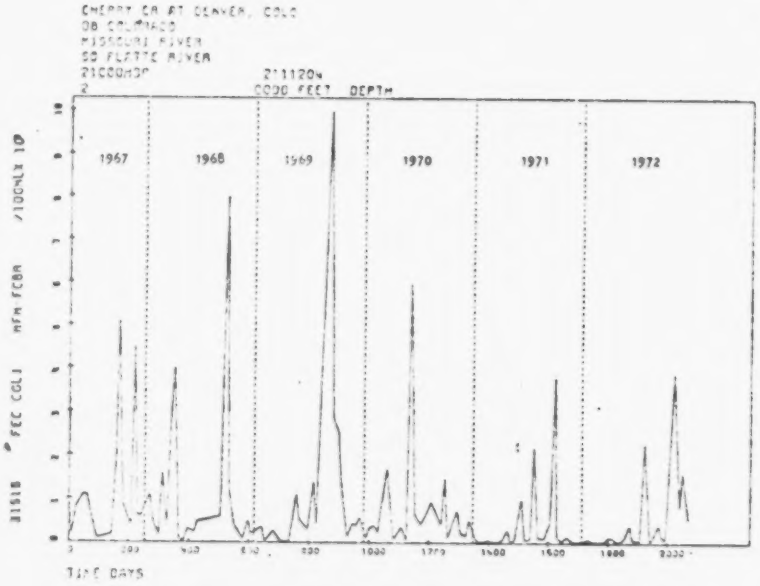

1968
1969
1970
1971
1972

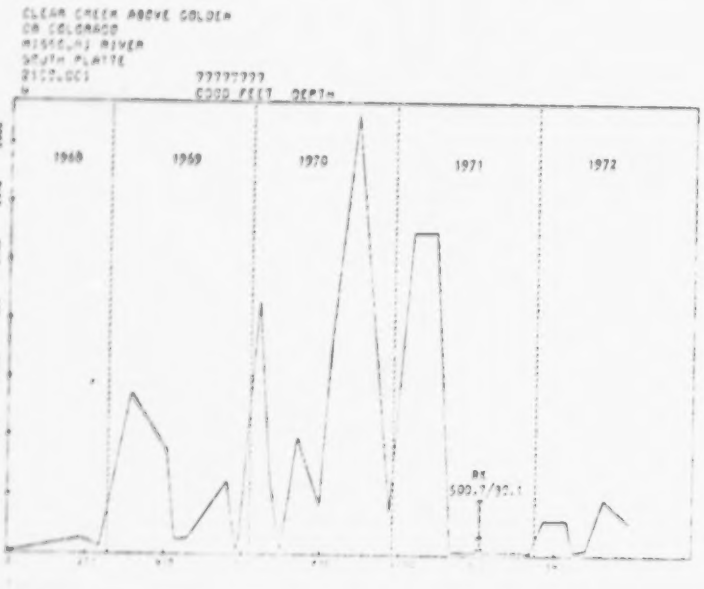

1968
1969
1970
1971
1972
TIME DAYS

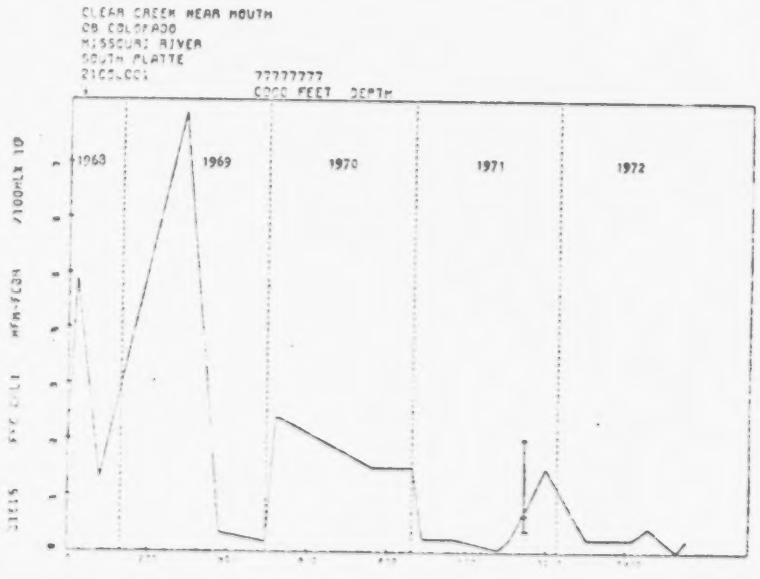

1968
1969
1970
1971
1972
TIME DAYS

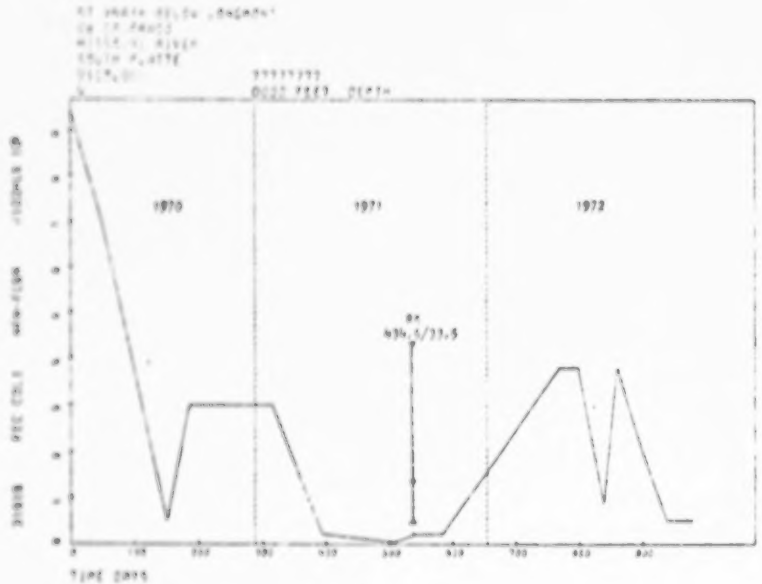

1968
1969
1970
1971
1972

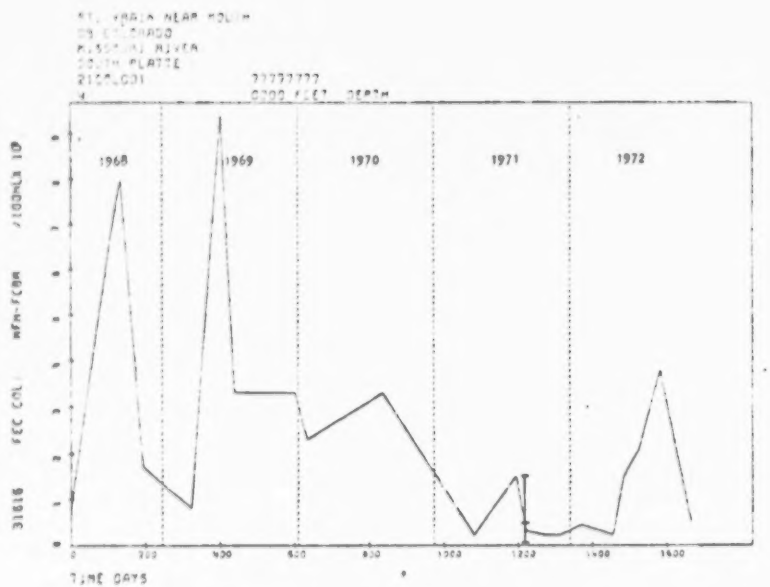

BEAR CREEK AT JEFF ARAP CO LINE
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21CO0201
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
TIME DAYS

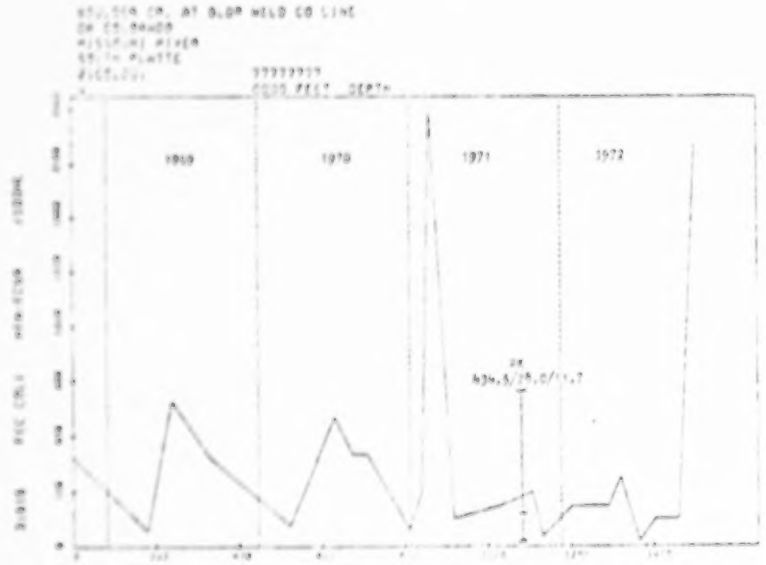

CHERRY CR AT DENVER, COLO
CO COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21CO0H3C
2'111204
0000 FEET DEPTH
1967
1968
1969
1970
1971
1972
TIME DAYS

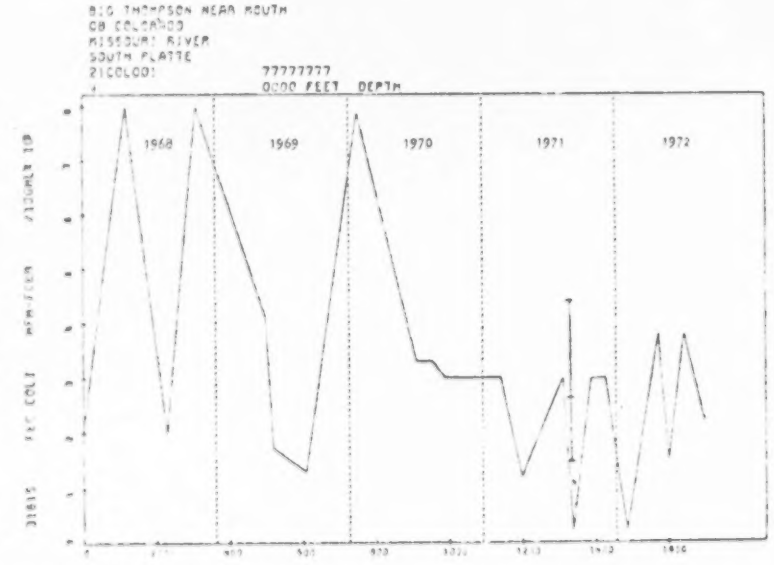

CLEAR CREEK ABOVE GOLDEN
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21CO0201
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972

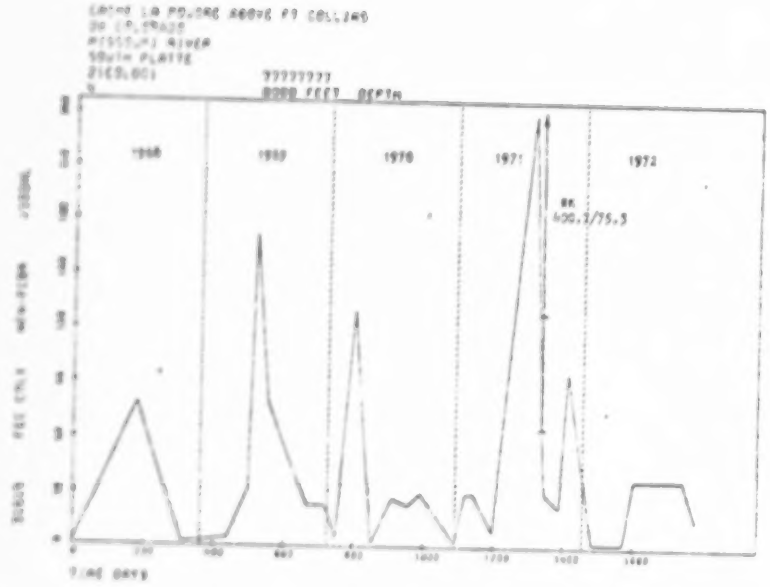

CLEAR CREEK NEAR MOUTH
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21CO0201
77777777
0000 FEET DEPTH
1963
1969
1970
1971
1972

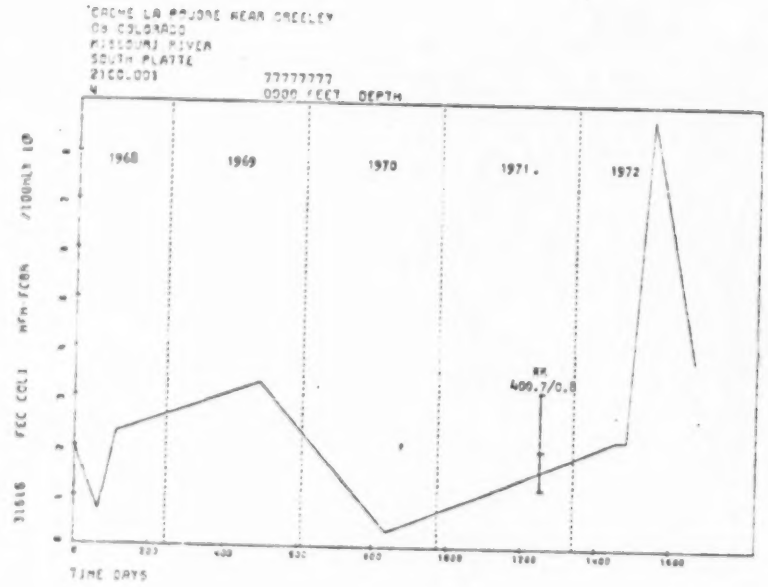

1970
1971
1972
TIME DAYS


1968
1969
1970
1971
1972
TIME DAYS


1969
1970
1971
1972

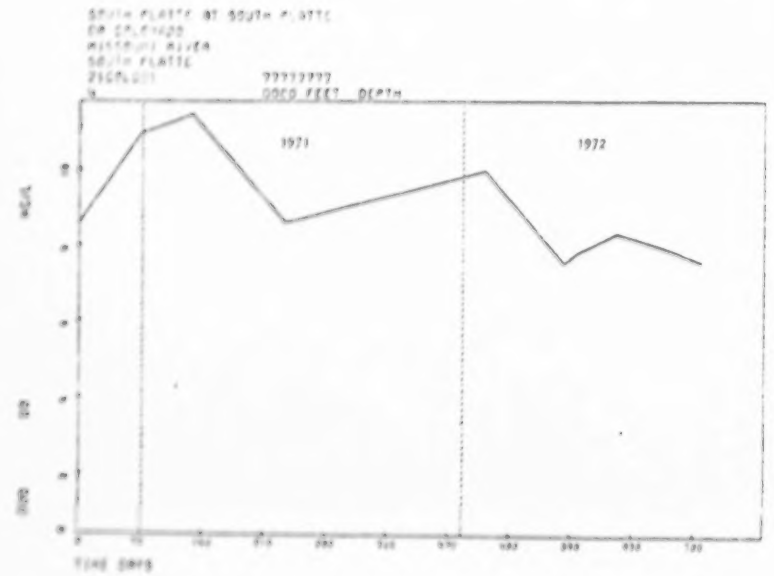

BIG THOMPSON NEAR MOUTH
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLCO01
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972

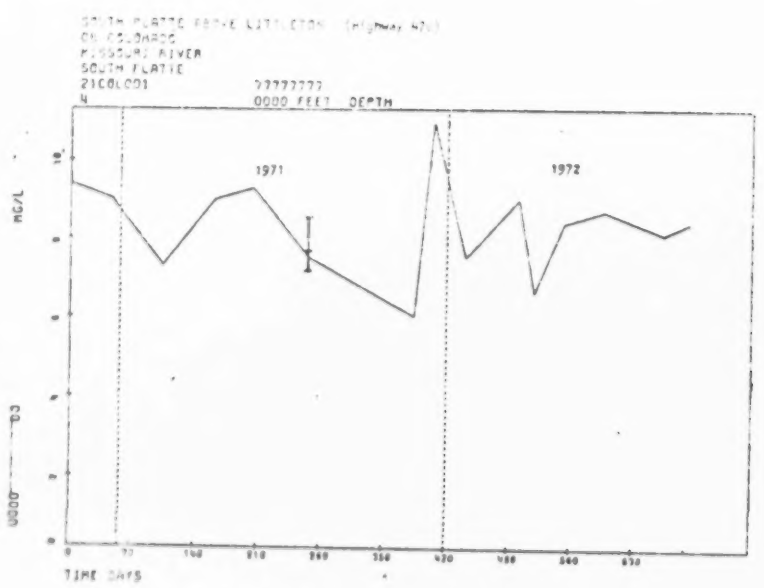

1968
1969
1970
1971
1972
RR
400.2/75.3
TIME DAYS

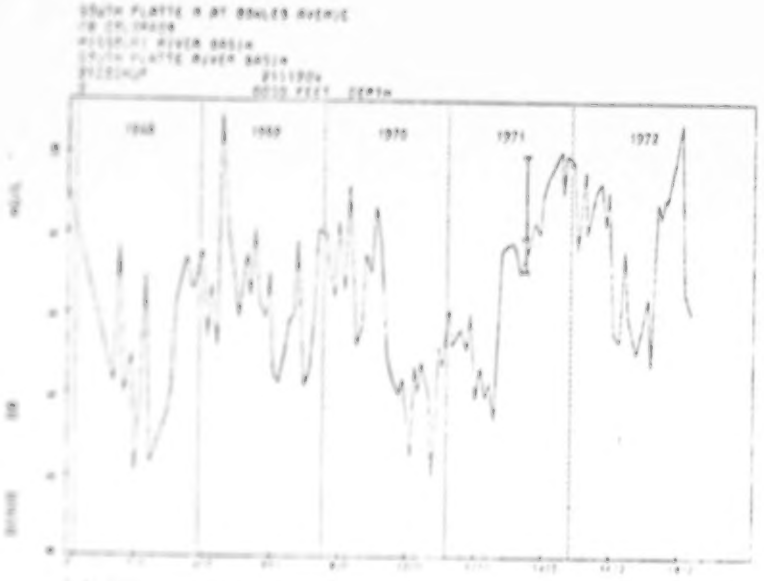

1968
1969
1970
1971.
1972
RR
400.7/0.8
TIME DAYS

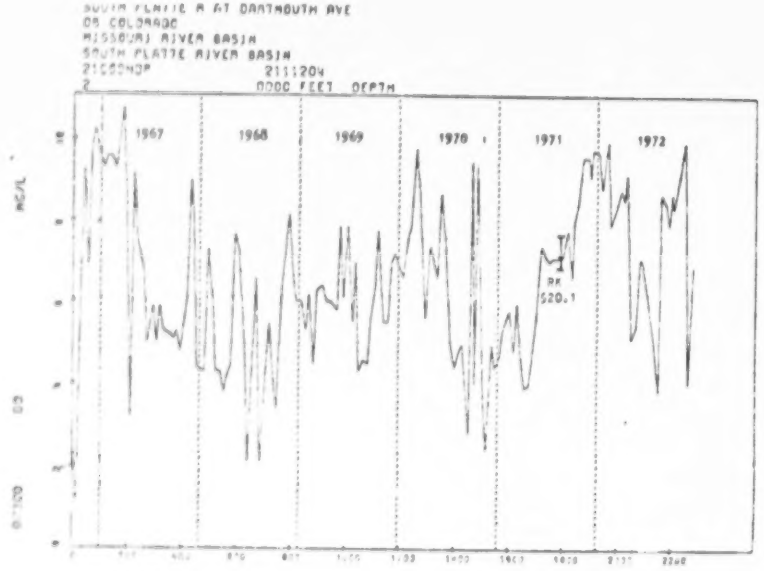
APPENDIX A - 3

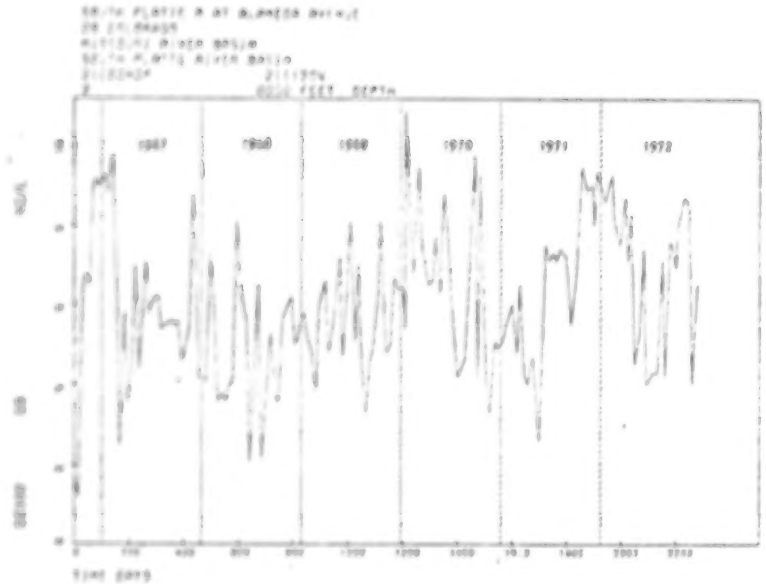
Computer Plots of Dissolved Oxygen Concentrations vs. Time at Long Term Water Quality Monitoring Stations in the South Platte River Basin

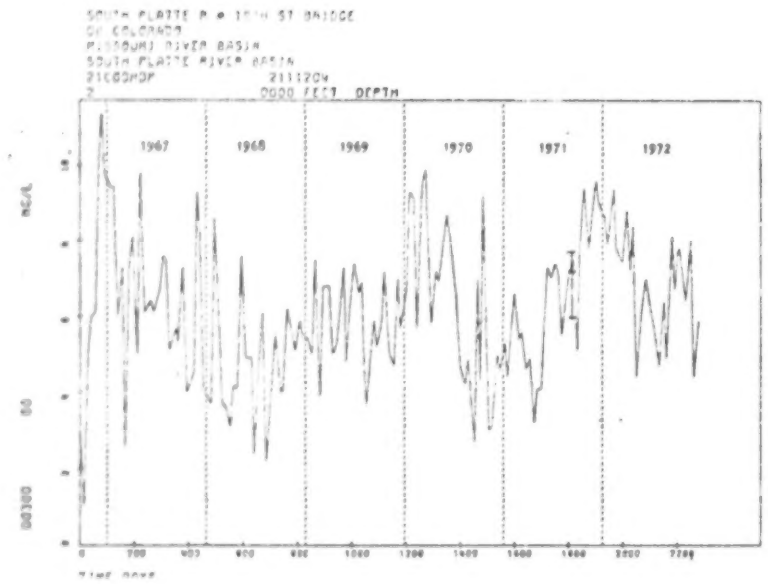

1971
1972
MG/L
TIME DAYS

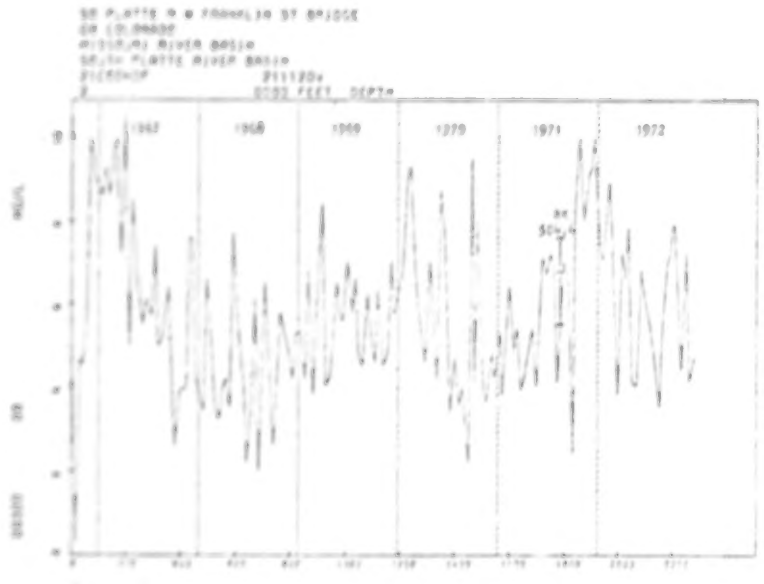

1971
1972
MG/L
TIME DAYS

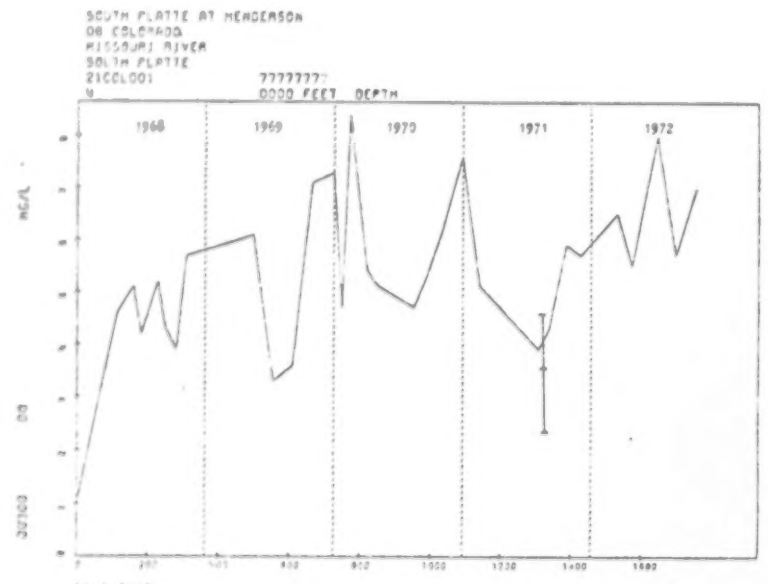

1968
1969
1970
1971
1972

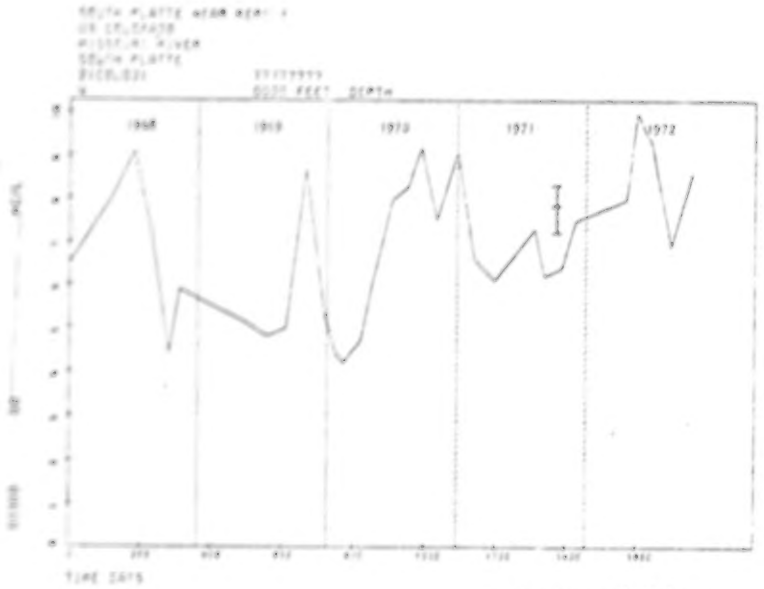

1967
1968
1969
1970
1971
1972
MG/L
520.1

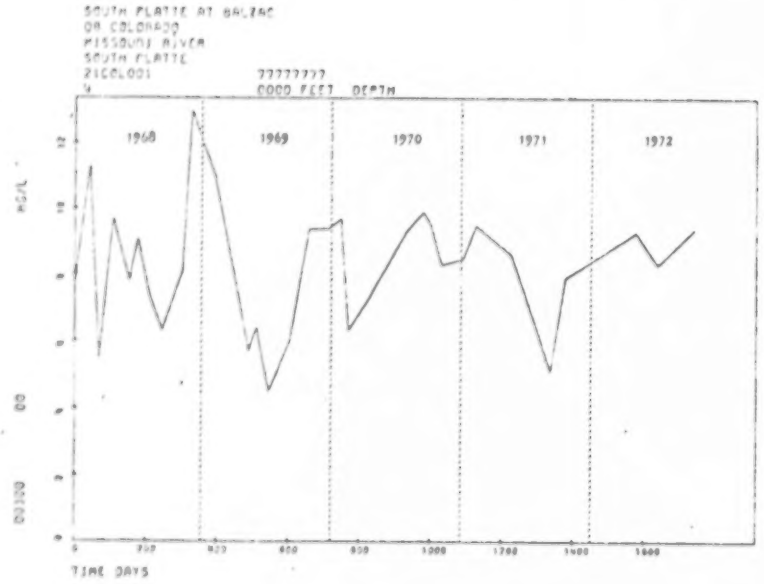

1967
1968
1969
1970
1971
1972

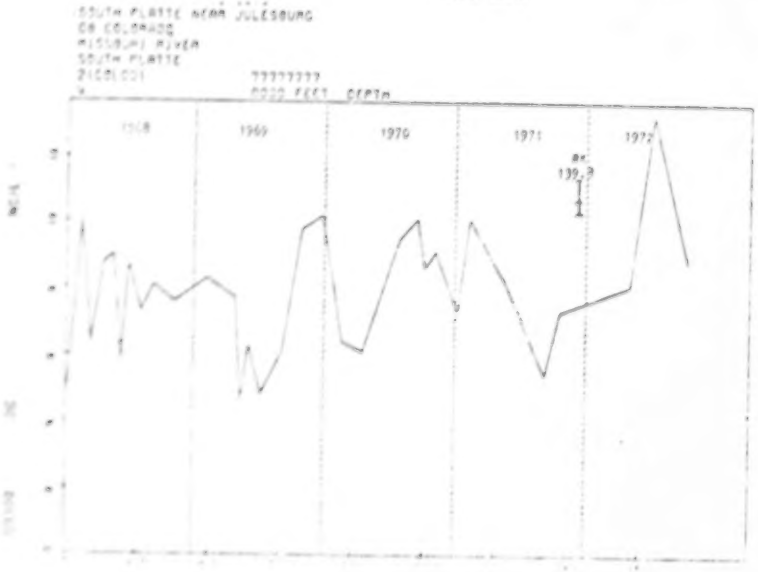

1967
1968
1969
1970
1971
1972

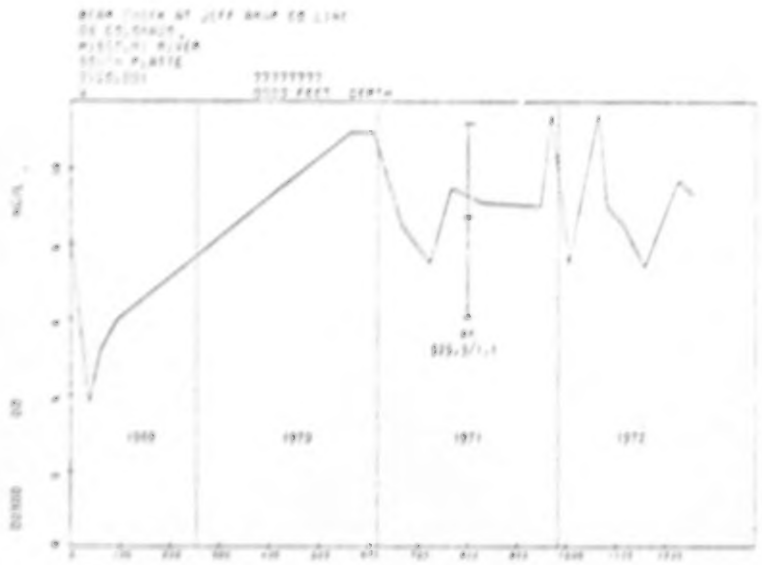

1967
1968
1969
1970
1971
1972

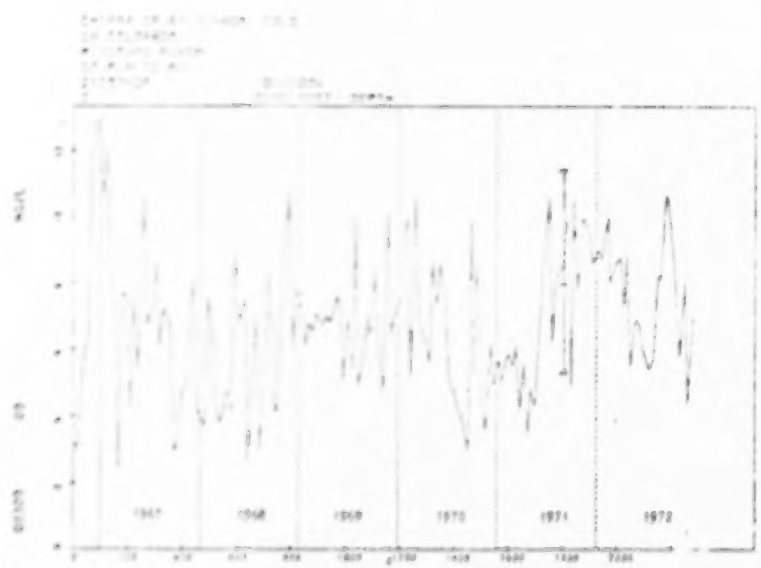

SOUTH PLATTE AT HENDERSON
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21CCL001 77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972

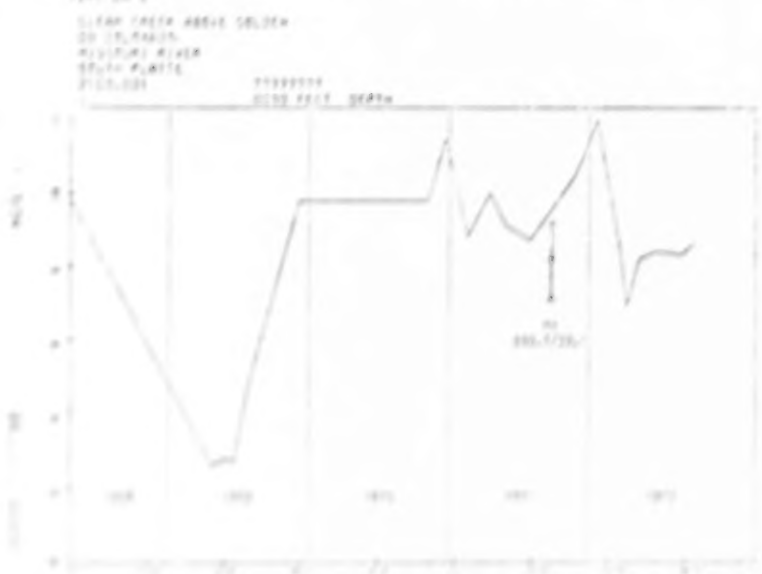

1968
1969
1970
1971
1972
TIME DAYS

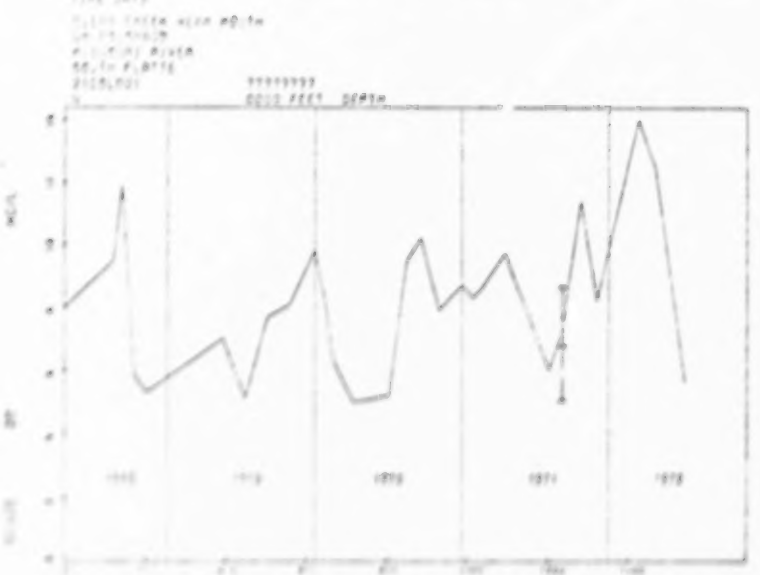

SOUTH PLATTE AT BALZAC
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
TIME DAYS


SOUTH PLATTE NEAR JULESBURG
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
139.2

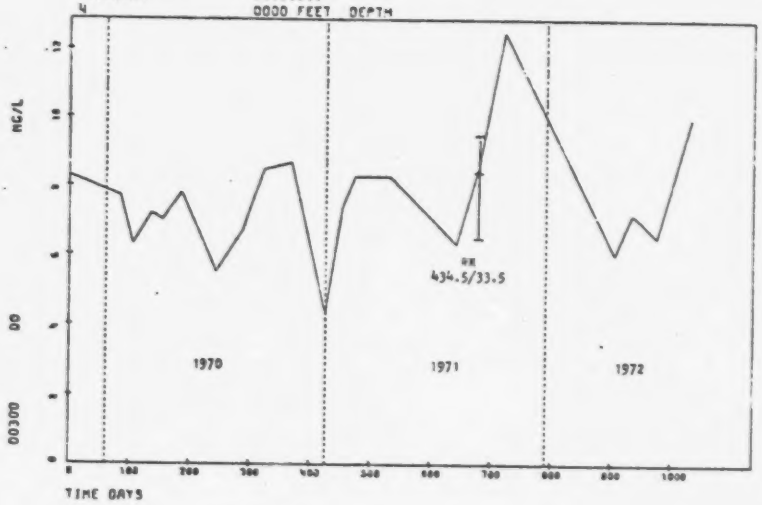

1970
1971
1972


1967
1968
1969
1970
1971
1972

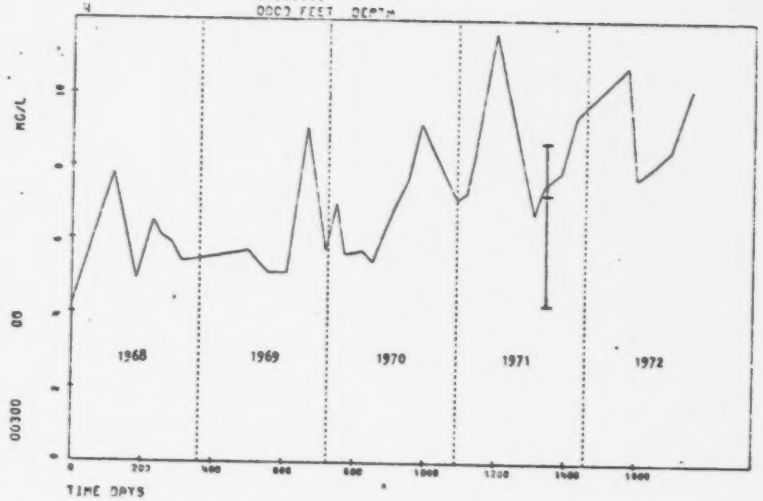




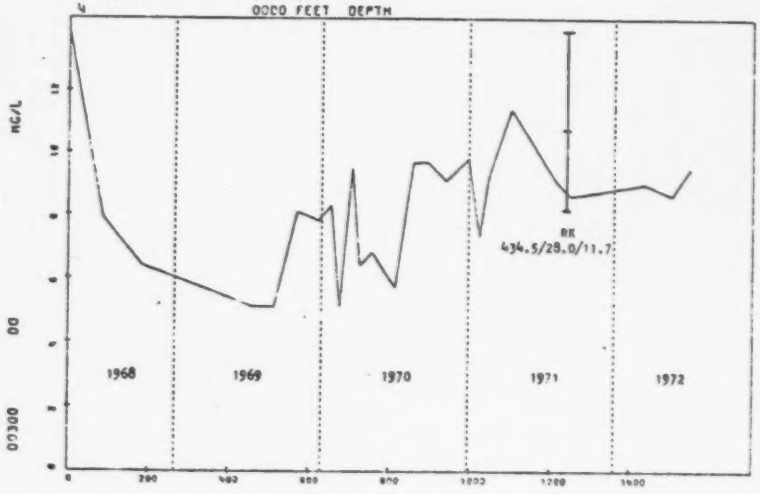
ST VRAIN BELOW LONGMONT
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH



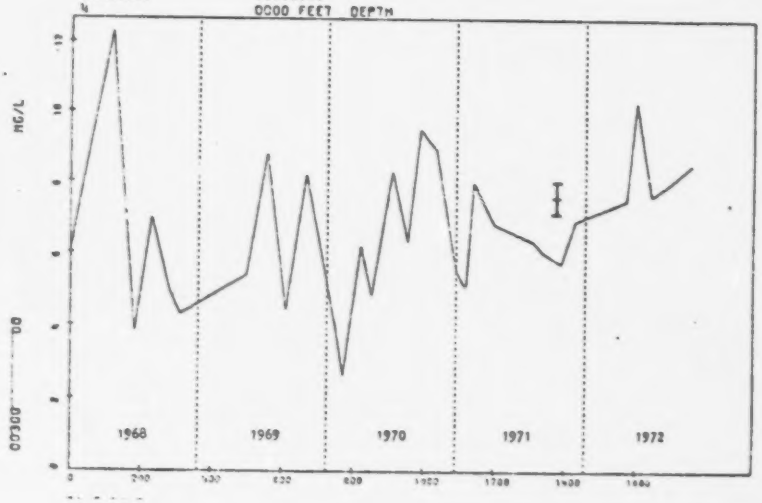
ST. VRAIN NEAR MOUTH
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH

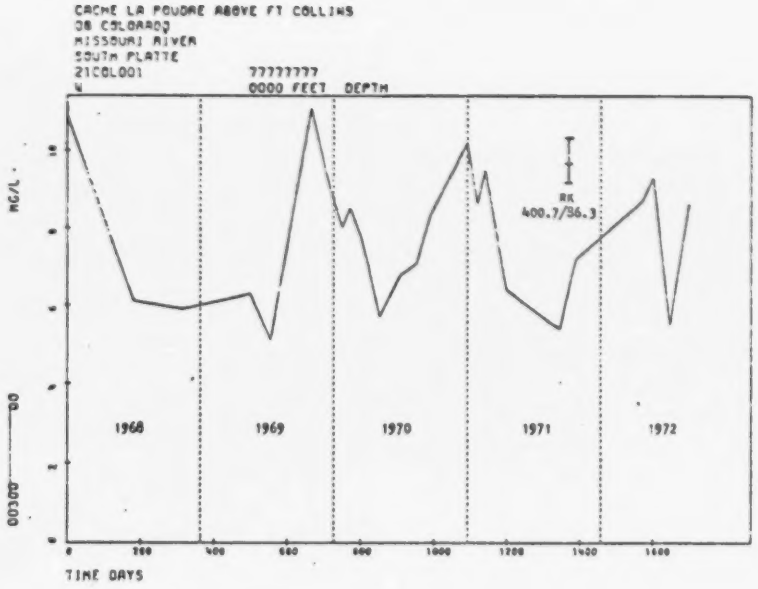


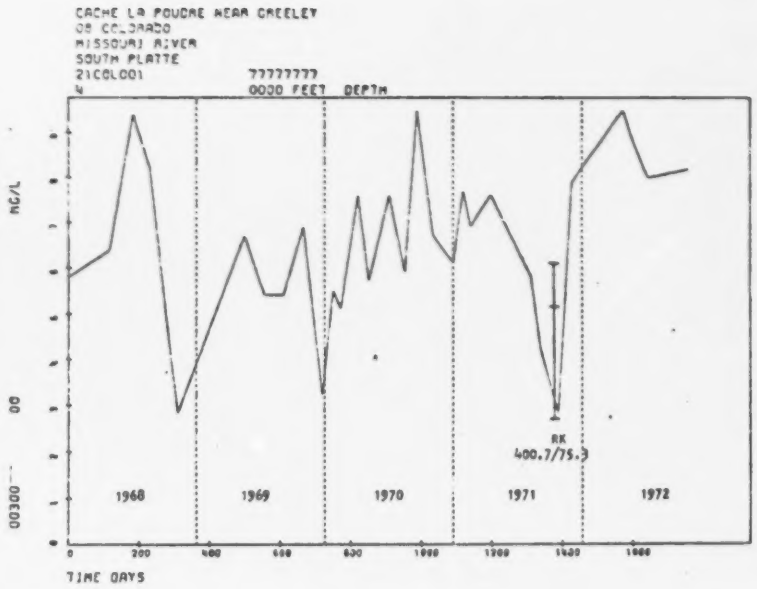
BOULDER CR. AT BLDR WELD CO LINE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH



BIG THOMPSON NEAR MOUTH
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH

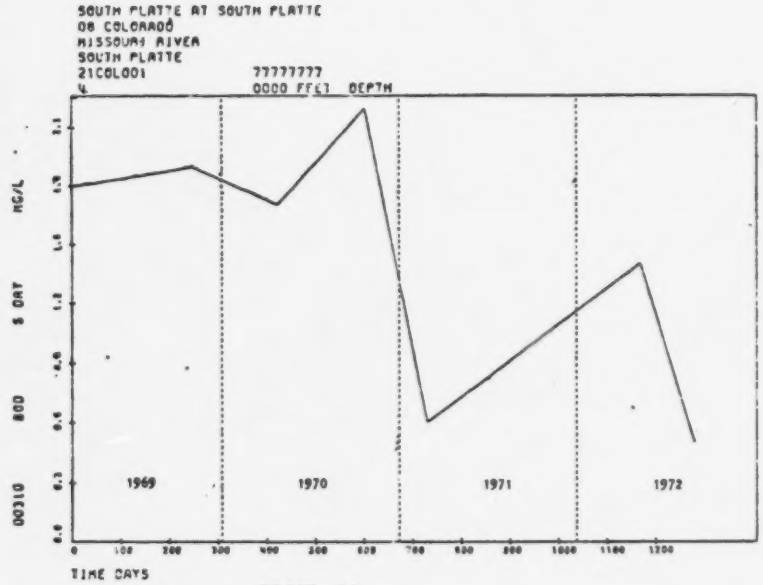


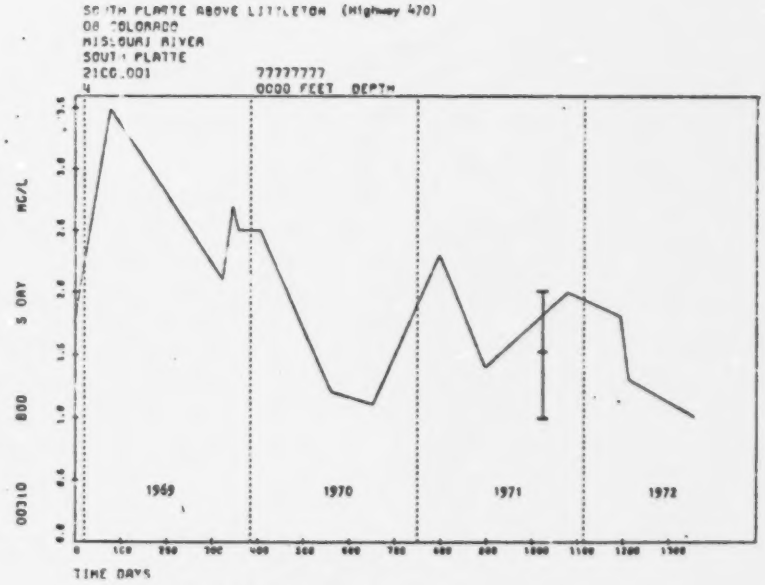

CACHE LA POUDRE ABOVE FT COLLINS
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
MG/L
00300
RK
400.7/86.3
1968
1969
1970
1971
1972
TIME DAYS

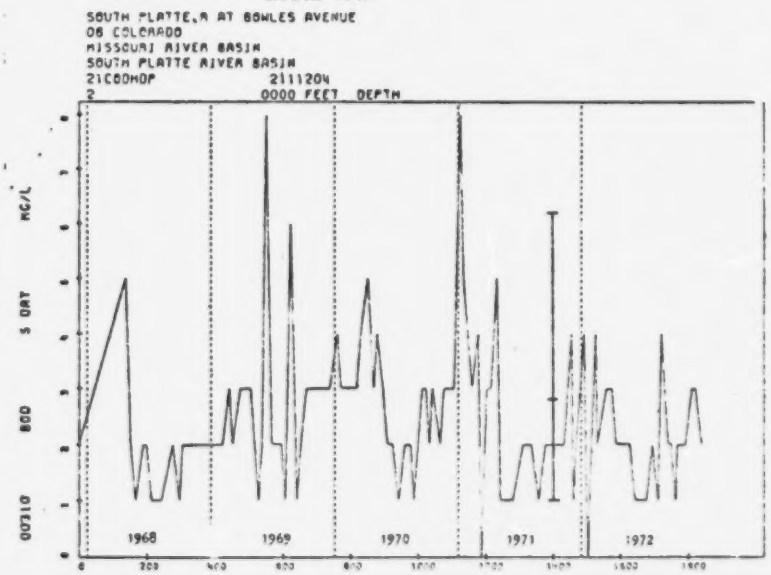

CACHE LA POUDRE NEAR GREELEY
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
MG/L
00300
RK
400.7/75.3
1968
1969
1970
1971
1972
TIME DAYS

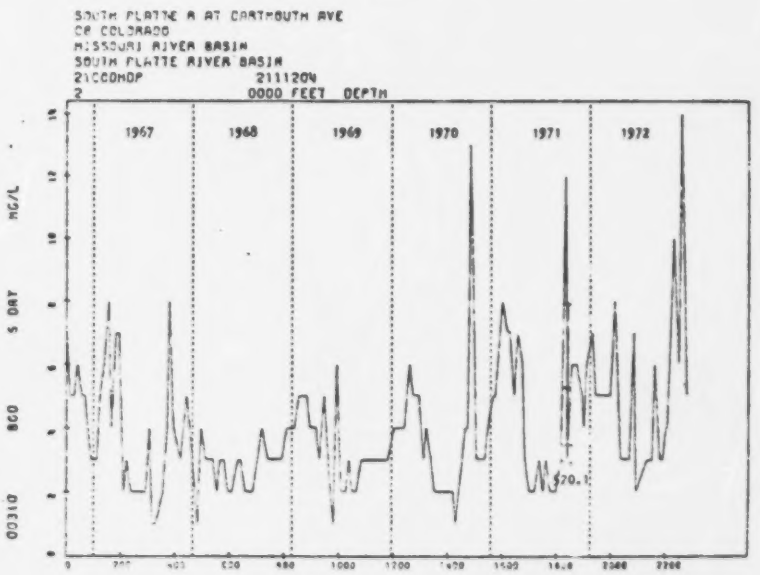
APPENDIX A - 4

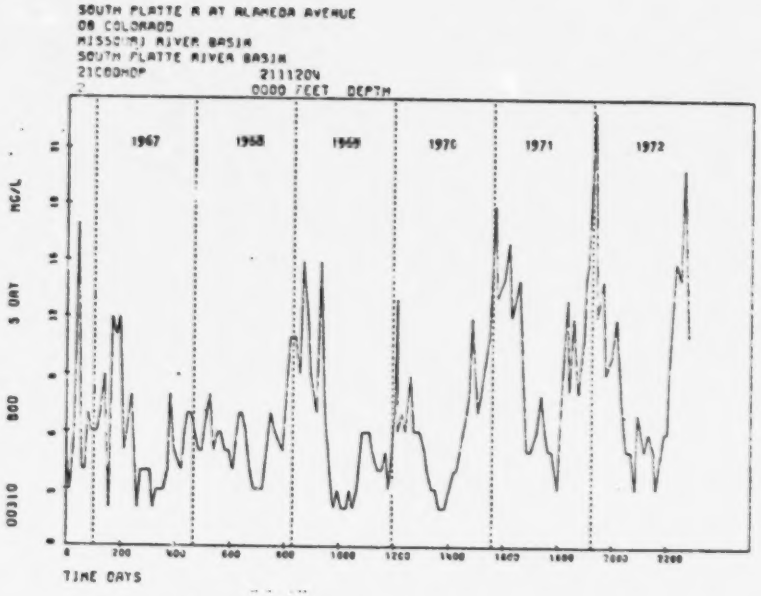
Computer Plots of 5-Day Biochemical Oxygen Demand Concentrations vs. Time at Long Term Water Quality Stations in the South Platte River Basin

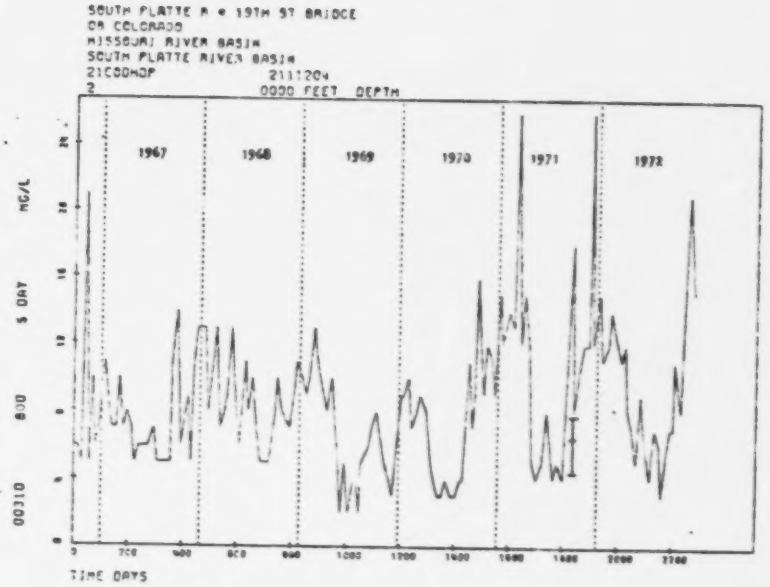

SOUTH PLATTE AT SOUTH PLATTE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH
00310 80D 5 DAY MG/L
1969
1970
1971
1972
TIME DAYS

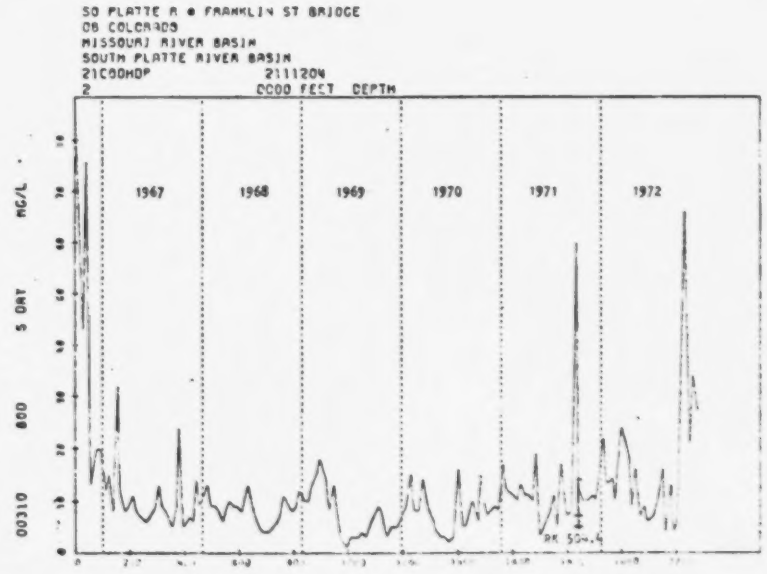

SOUTH PLATTE ABOVE LITTLETON (Highway 470)
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21CO.001 77777777
4 0000 FEET DEPTH
00310 80D 5 DAY MG/L
1969
1970
1971
1972
TIME DAYS

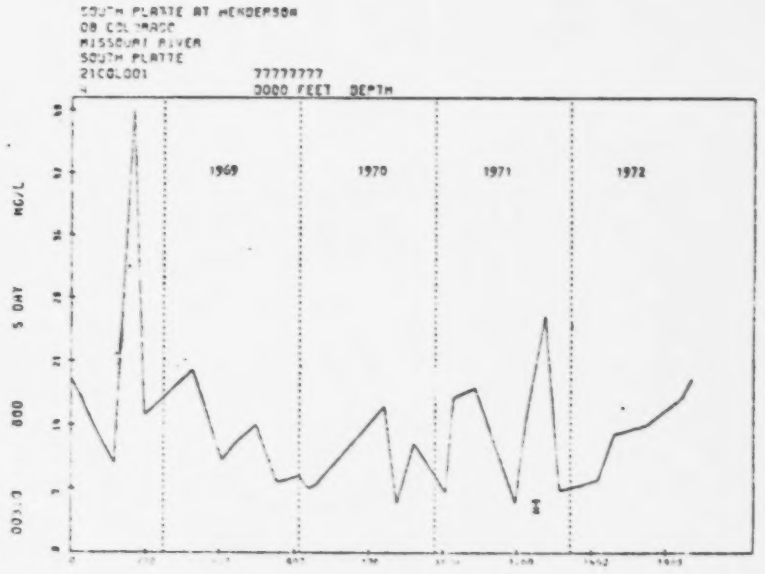

SOUTH PLATTE,A AT BOWLES AVENUE
08 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21CO0H0P 2111204
2 0000 FEET DEPTH
00310 80D 5 DAY MG/L
1968
1969
1970
1971
1972

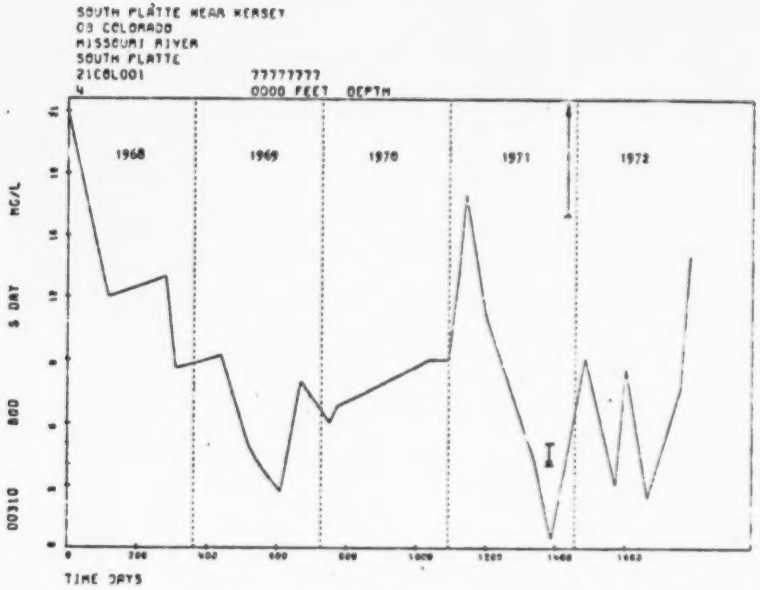

SOUTH PLATTE R AT DARTMOUTH AVE
08 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21CO0H0P 2111204
2 0000 FEET DEPTH
00310 80D 5 DAY MG/L
1967
1968
1969
1970
1971
1972

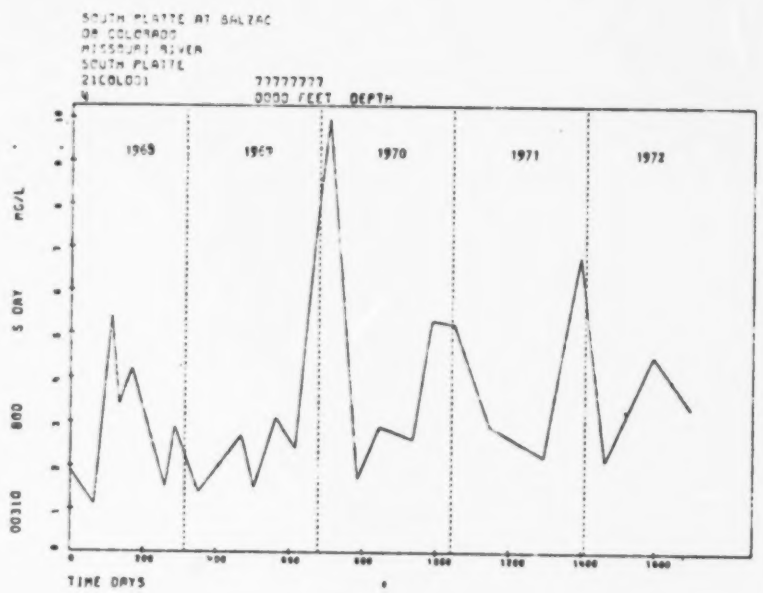

SOUTH PLATTE R AT ALAMEDA AVENUE
OB COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HDP 2111204
0000 FEET DEPTH
1967
1968
1969
1970
1971
1972
00310 BOD 5 DAY MG/L
TIME DAYS

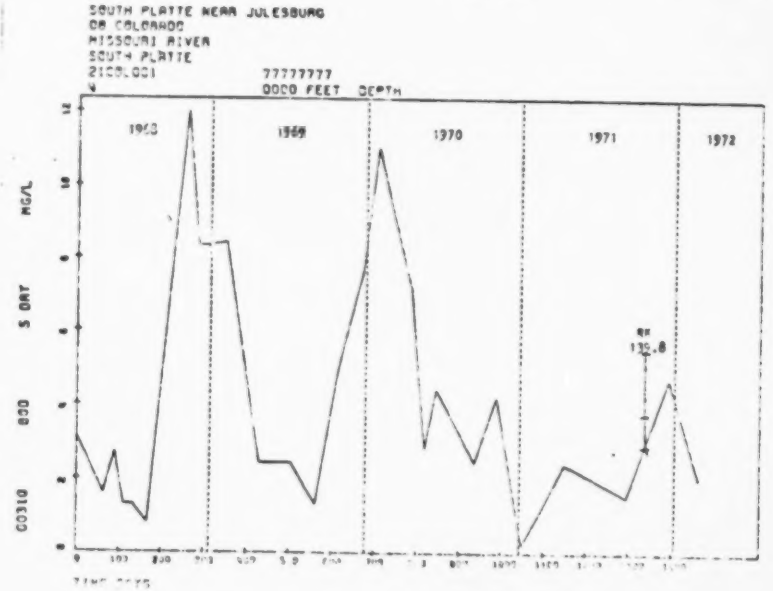

SOUTH PLATTE R @ 19TH ST BRIDGE
OB COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HDP 2111204
0000 FEET DEPTH
1967
1968
1969
1970
1971
1972
00310 BOD 5 DAY MG/L
TIME DAYS

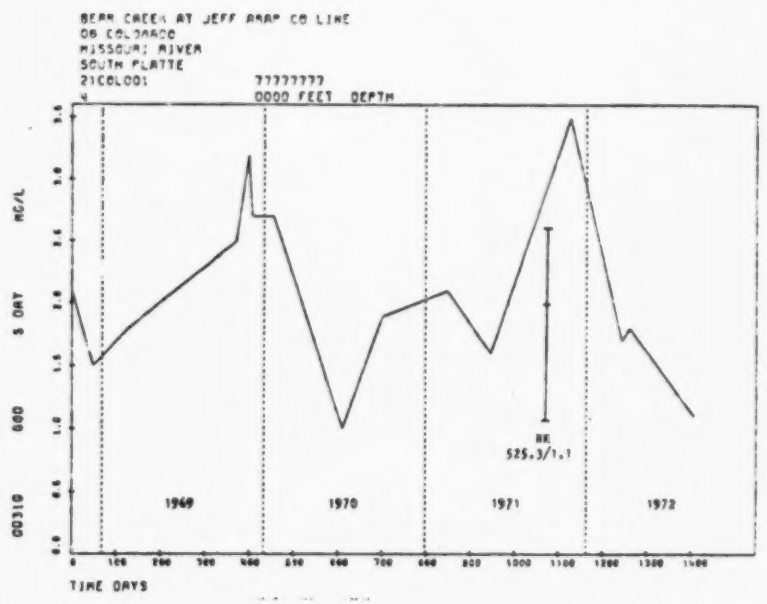

SO PLATTE R @ FRANKLIN ST BRIDGE
OB COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HDP 2111204
0000 FEET DEPTH
1967
1968
1969
1970
1971
1972
00310 BOD 5 DAY MG/L

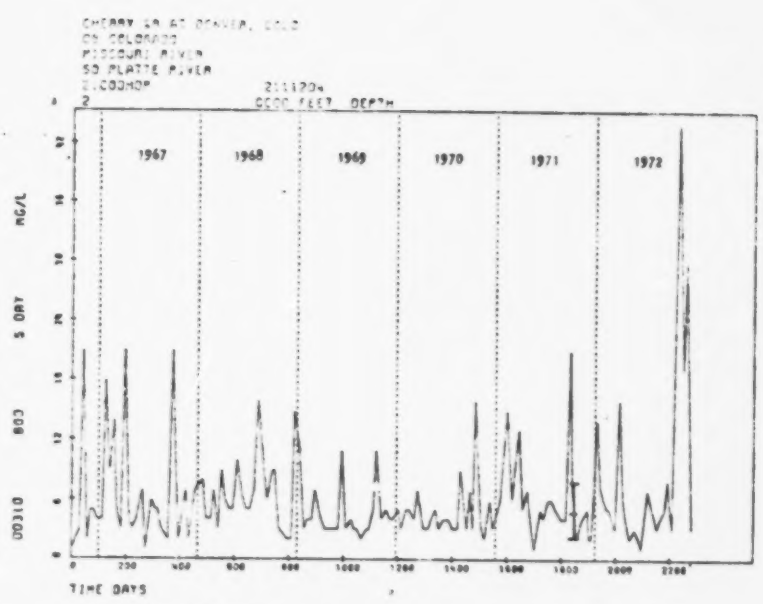

SOUTH PLATTE AT HENDERSON
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21C0L001 77777777
0000 FEET DEPTH
1969
1970
1971
1972
00310 BOD 5 DAY MG/L

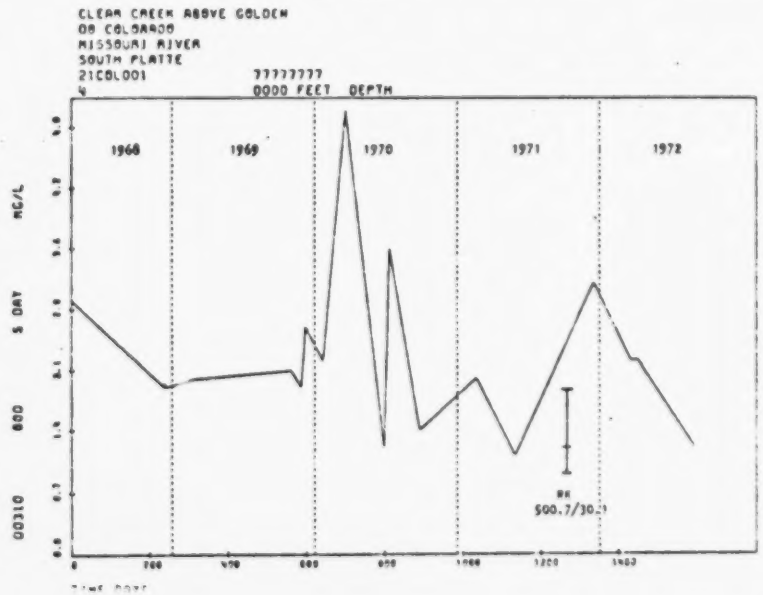

SOUTH PLATTE NEAR KERSEY
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01 77777777
4 0000 FEET DEPTH
1968
1969
1970
1971
1972
00310 80D 5 DAY MG/L
TIME DAYS

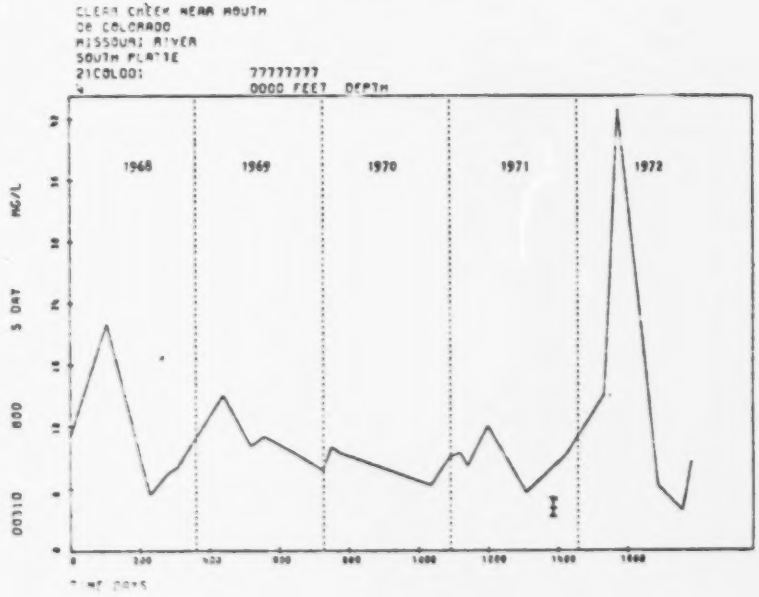

SOUTH PLATTE AT BALZAC
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01 77777777
4 0000 FEET DEPTH
1969
1970
1971
1972
00310 80D 5 DAY MG/L
TIME DAYS

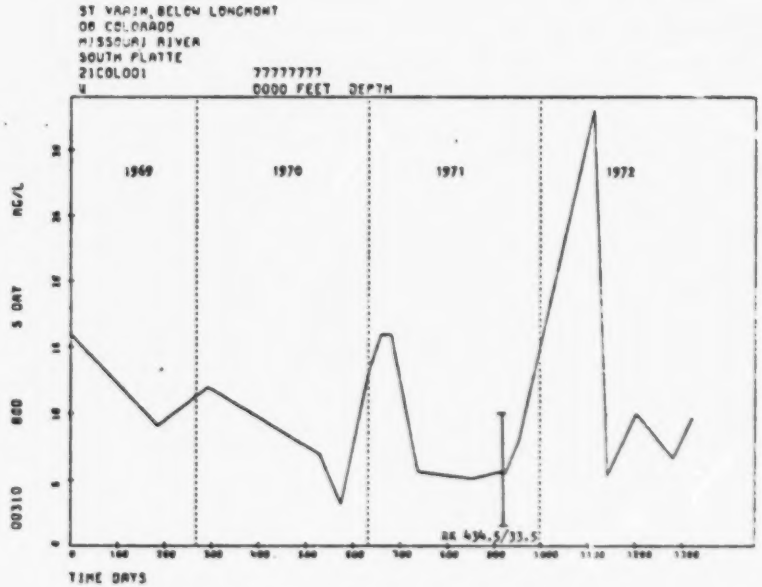

SOUTH PLATTE NEAR JULESBURG
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01 77777777
4 0000 FEET DEPTH
1970
1971
1972
00310 80D 5 DAY MG/L
TIME DAYS

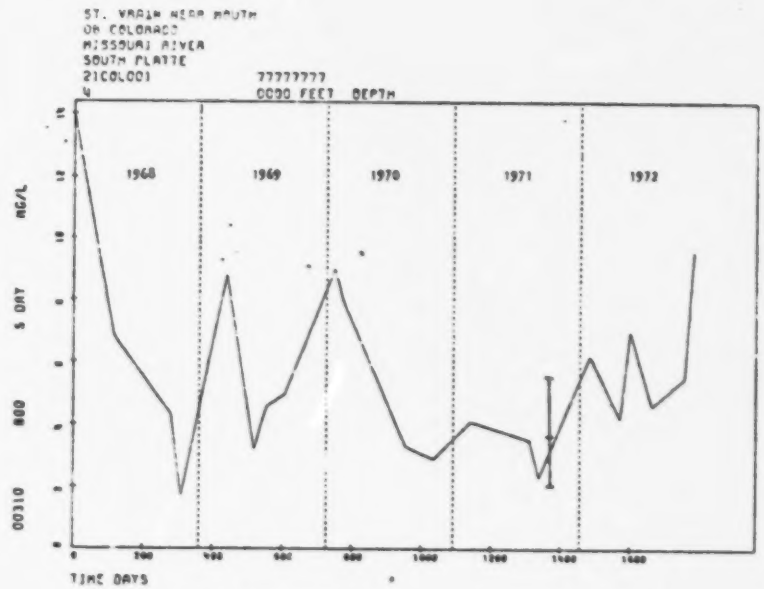

BEAR CREEK AT JEFF ANAP CO LINE
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
0000 FEET DEPTH
00310 BOD 5 DAY MG/L
1969
1970
1971
1972
TIME DAYS

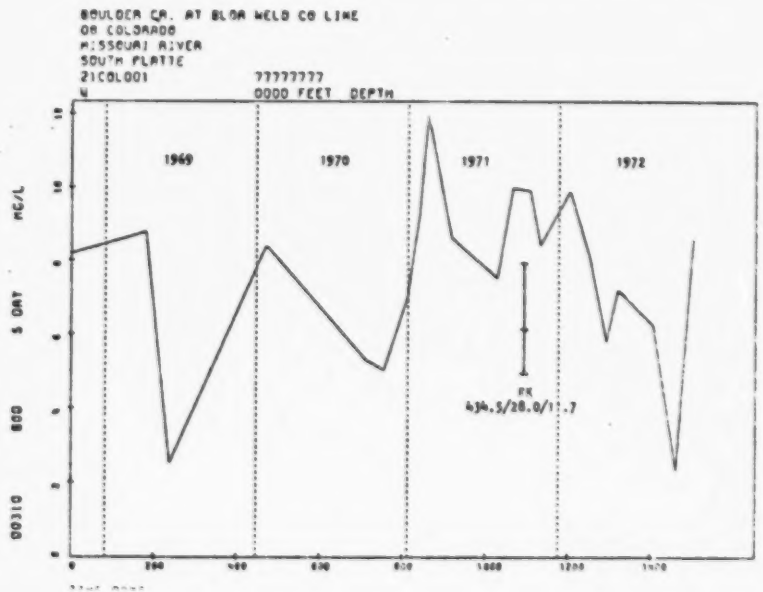

CHERRY CR AT DENVER, COLO
OB COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21COL040
0000 FEET DEPTH
00310 BOD 5 DAY MG/L
1967
1968
1969
1970
1971
1972
TIME DAYS

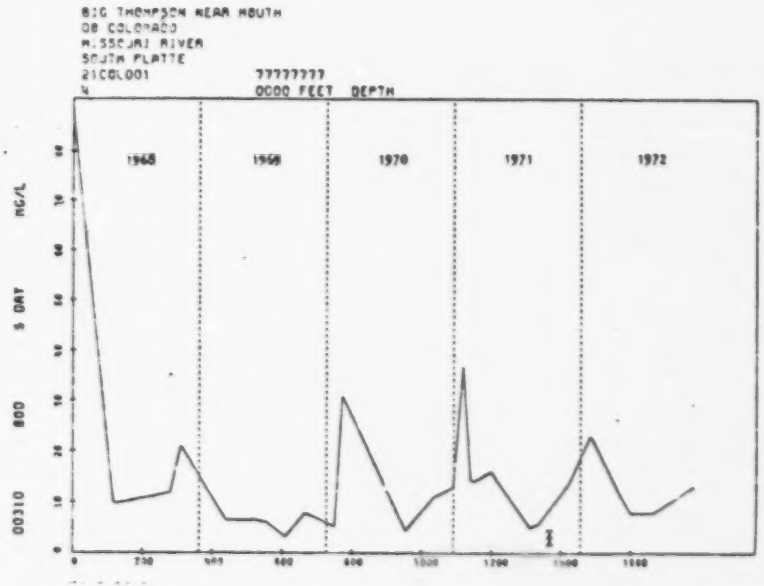

CLEAR CREEK ABOVE GOLDEN
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
0000 FEET DEPTH
00310 BOD 5 DAY MG/L
1968
1969
1970
1971
1972

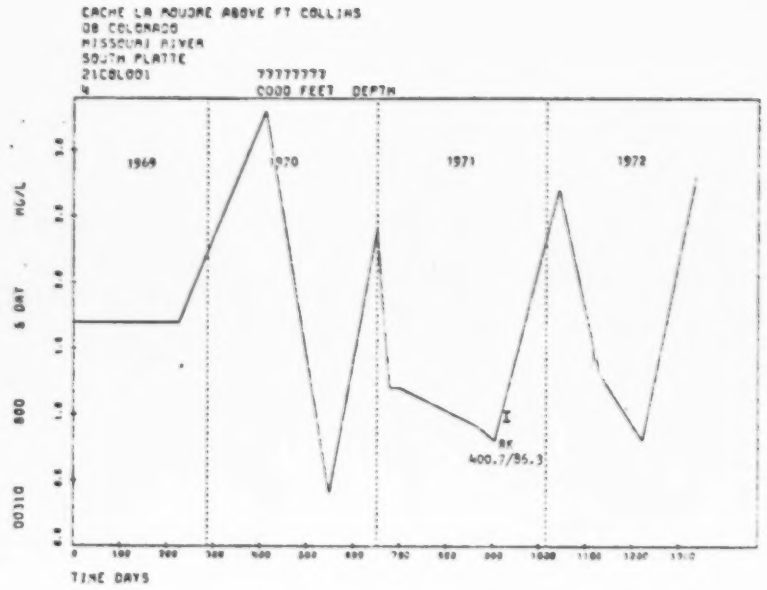

CLEAR CREEK NEAR MOUTH
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
0000 FEET DEPTH
00310 BOD 5 DAY MG/L
1968
1969
1970
1971
1972

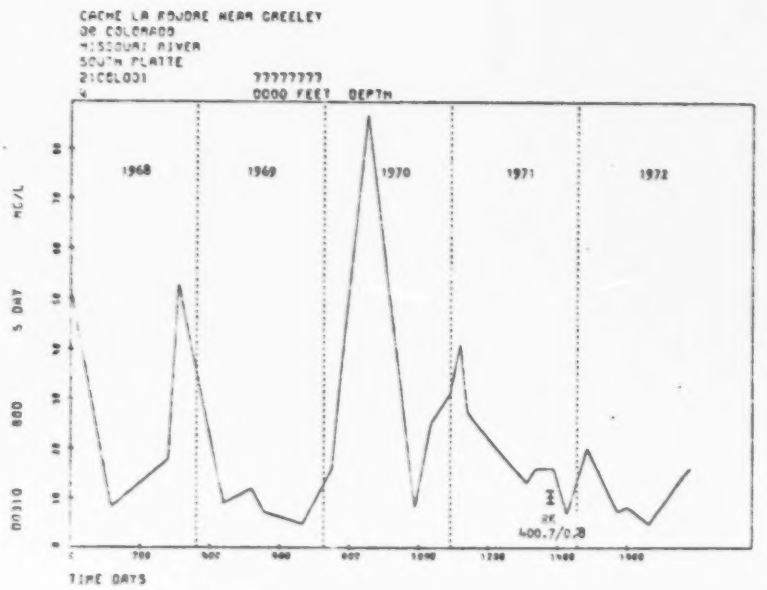

ST VRAIN, BELOW LONGMONT
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
W 0000 FEET DEPTH
1969
1970
1971
1972
00310 80D 5 DAY MG/L
RK 434.5/33.5
TIME DAYS


ST. VRAIN NEAR MOUTH
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
W 0000 FEET DEPTH
1968
1969
1970
1971
1972
00310 80D 5 DAY MG/L
TIME DAYS


BOULDER CR. AT BLDR WELD CO LINE
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
W 0000 FEET DEPTH
1969
1970
1971
1972
00310 80D 5 DAY MG/L
RK
434.5/28.0/11.7


BIG THOMPSON NEAR MOUTH
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
W 0000 FEET DEPTH
1968
1969
1970
1971
1972
00310 80D 5 DAY MG/L

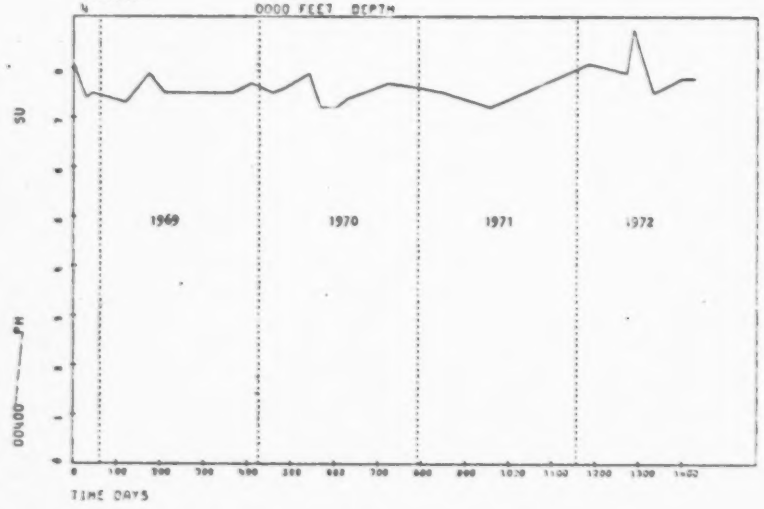

CACHE LA POUDRE ABOVE FT COLLINS
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00310 5 DAY MG/L
TIME DAYS
400.7/86.3


CACHE LA POUDRE NEAR GREELEY
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO31
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
00310 5 DAY MG/L
TIME DAYS
400.7/0.28

APPENDIX A - 5

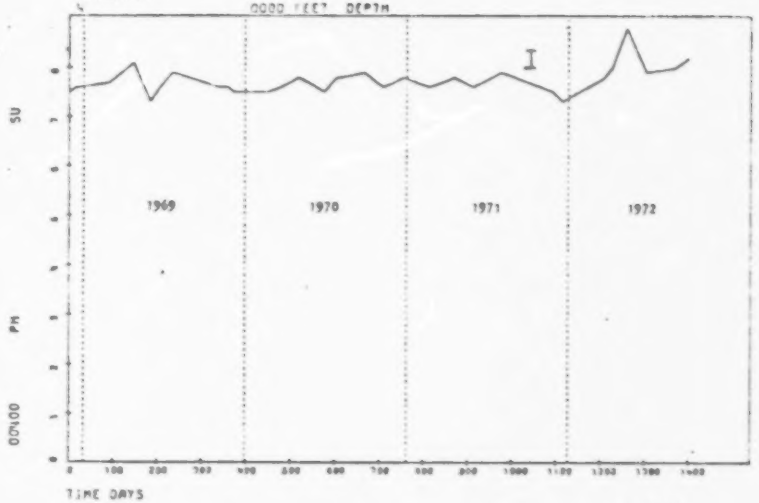
Computer Plots of Hydrogen Ion Concentrations (pH) vs. Time at Long Term Water Quality Monitoring Stations in the South Platte River Basin

SOUTH PLATTE AT SOUTH PLATTE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01 77777777
4 0000 FEET DEPTH



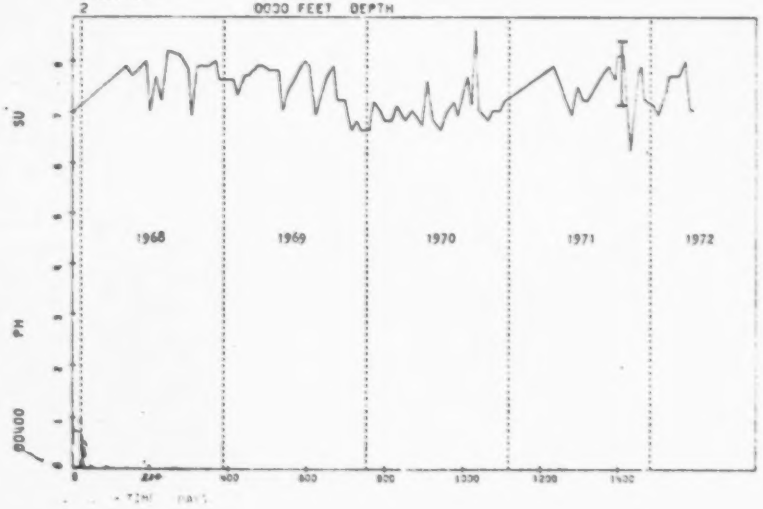
TIME DAYS

SOUTH PLATTE ABOVE LITTLETON (Highway 470)
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01 77777777
5 0000 FEET DEPTH



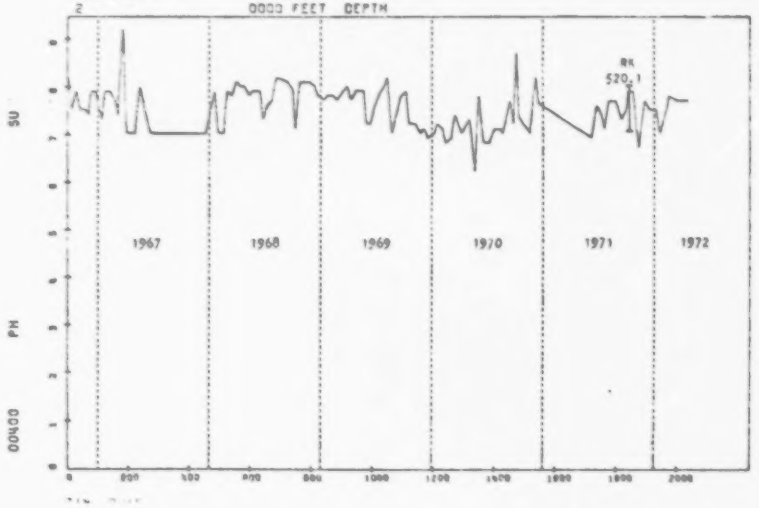
TIME DAYS

SO. PLATTE R AT LITTLETON, COLO (Bowles Avenue)
08 COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21COOHOP 2111204
2 0000 FEET DEPTH

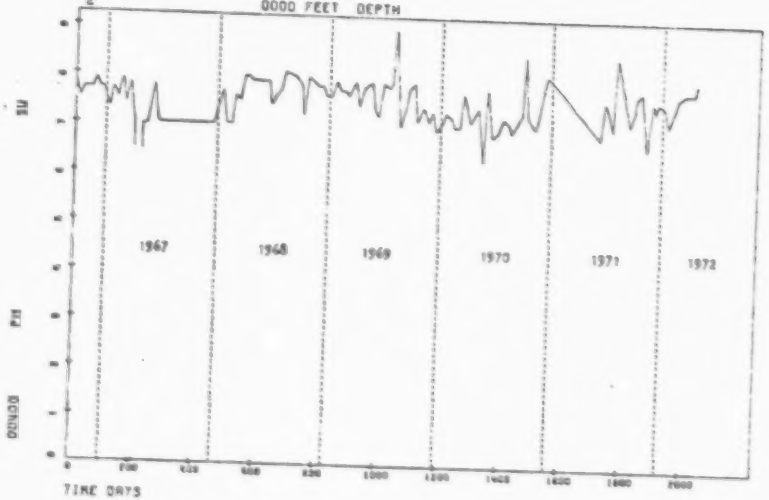


TIME DAYS

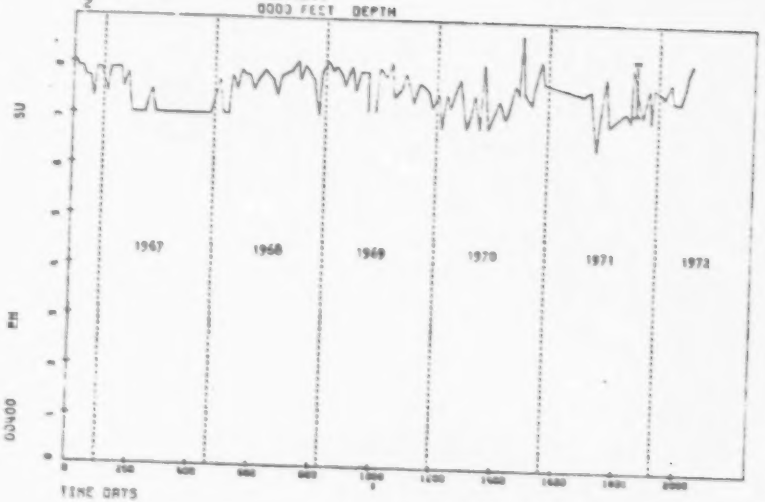
SO. PLATTE R AT ENGLEWOOD, COLO (Dartmouth Ave.)
08 COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21COOHOP 2111204
2 0000 FEET DEPTH

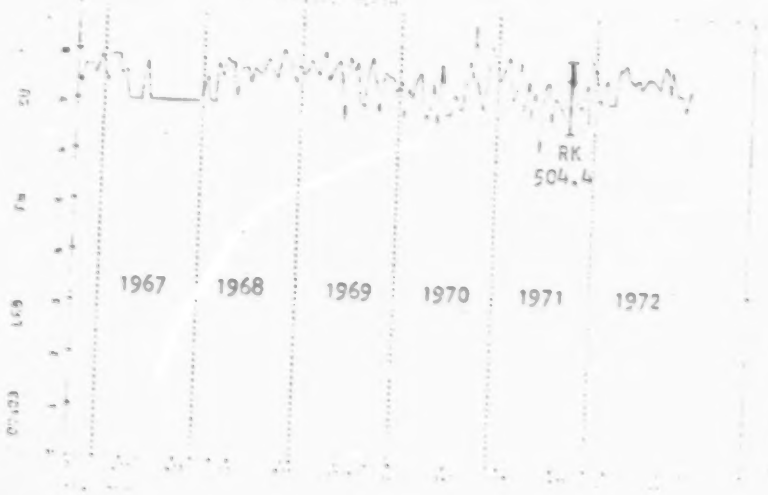


SO. PLATTE R AT DENVER, COLO (Alameda Ave.)
08 COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21C00HOP
2
2111204
0000 FEET DEPTH

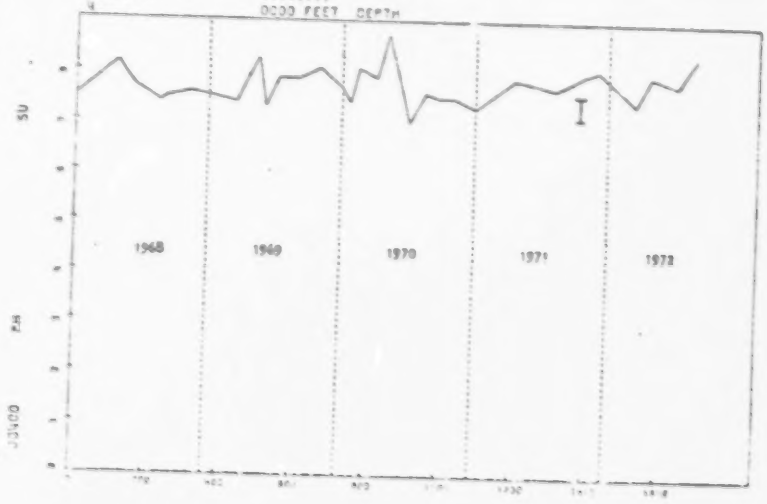


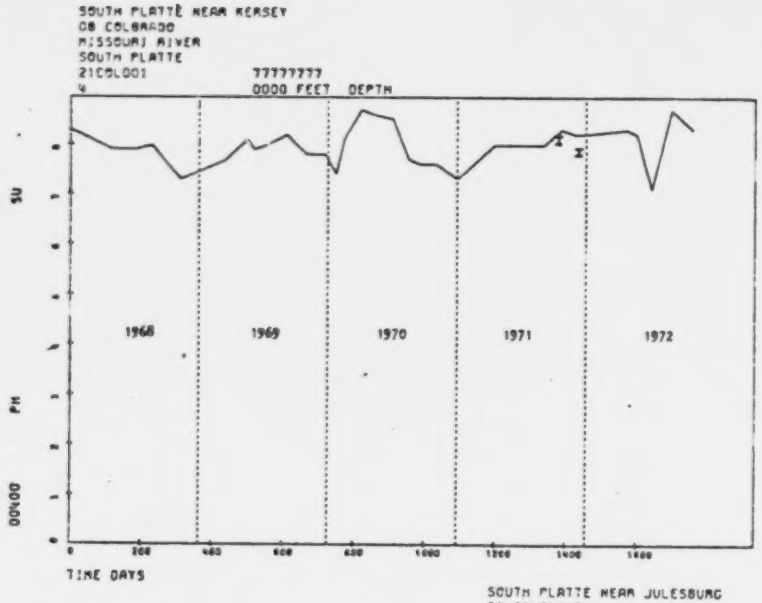
SO. PLATTE R AT DENVER, COLO (19th Street)
08 COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21C00HOP
2
2111204
0000 FEET DEPTH

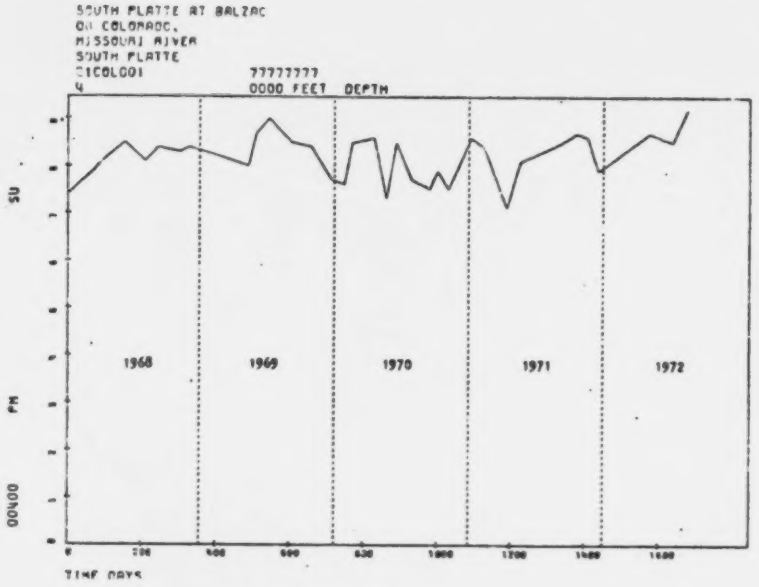


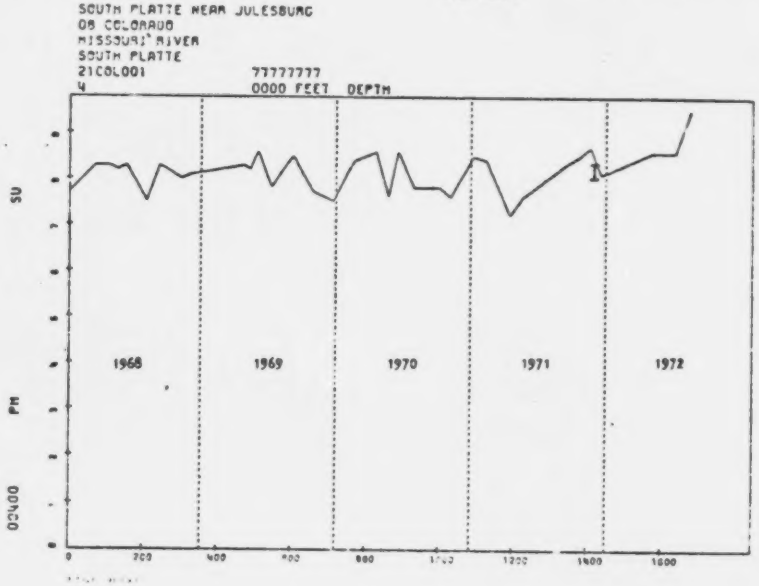


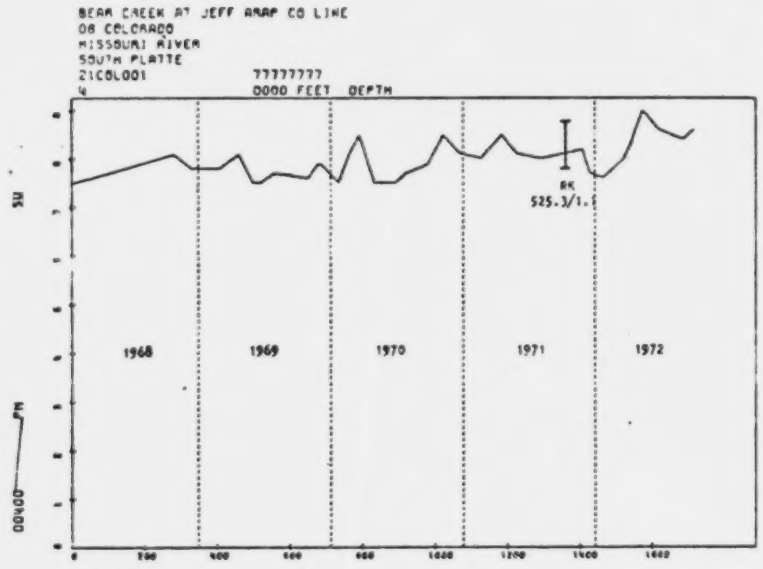
SOUTH PLATTE AT HENDERSON
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21C00L021
4
77777777
0000 FEET DEPTH

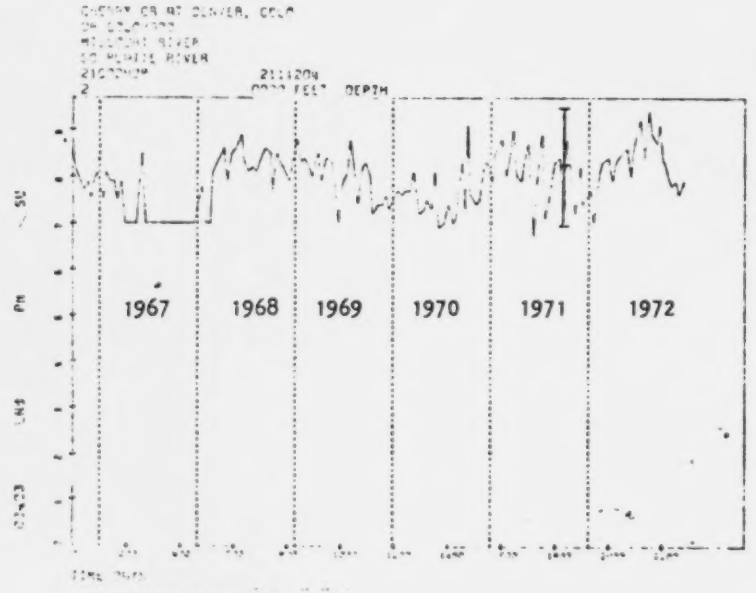


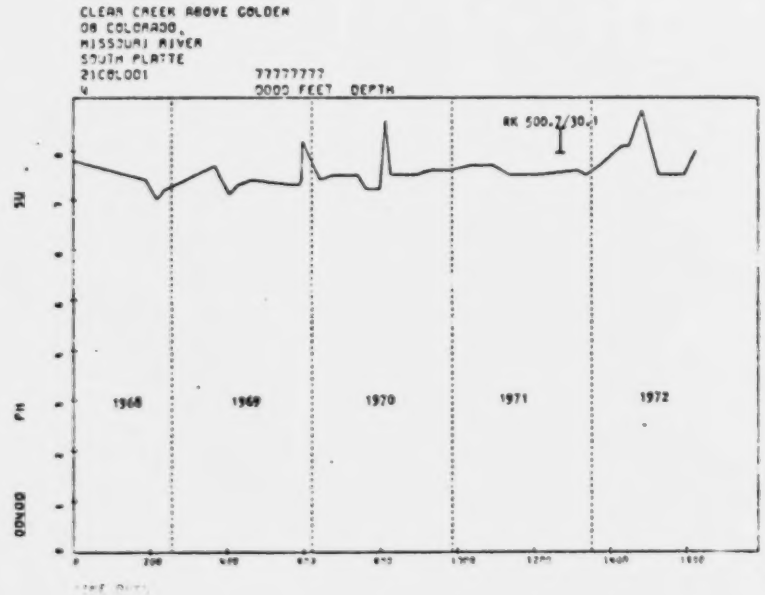

SOUTH PLATTE NEAR KERSEY
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH
SU
PH
00400
1968
1969
1970
1971
1972
TIME DAYS

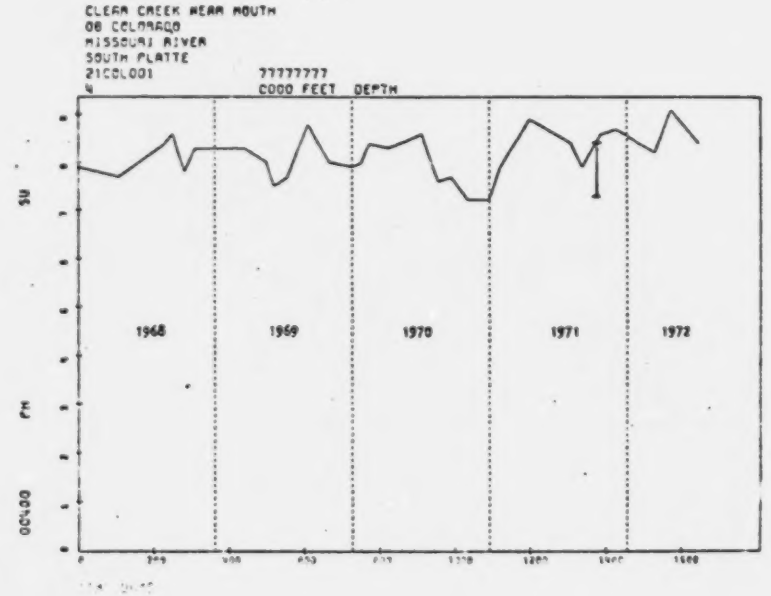

SOUTH PLATTE AT BALZAC
OR COLORADO,
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH
SU
PH
00400
1968
1969
1970
1971
1972
TIME DAYS

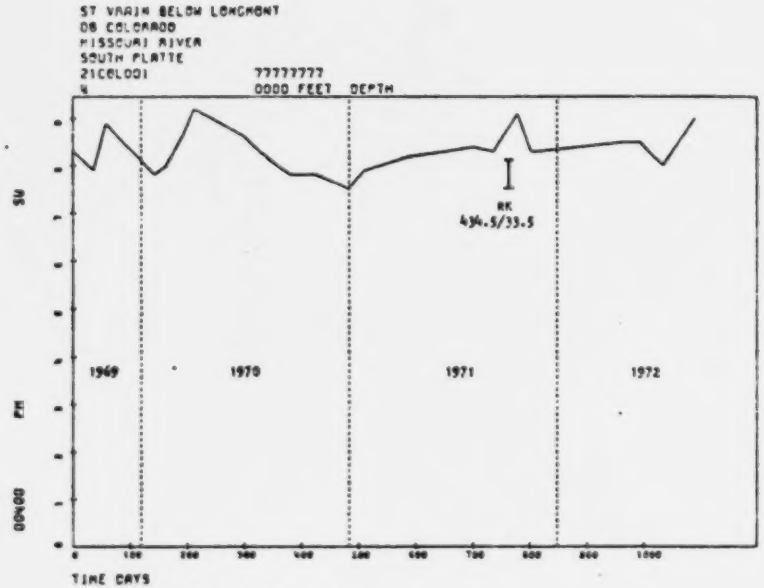

SOUTH PLATTE NEAR JULESBURG
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH
SU
PH
00400
1968
1969
1970
1971
1972

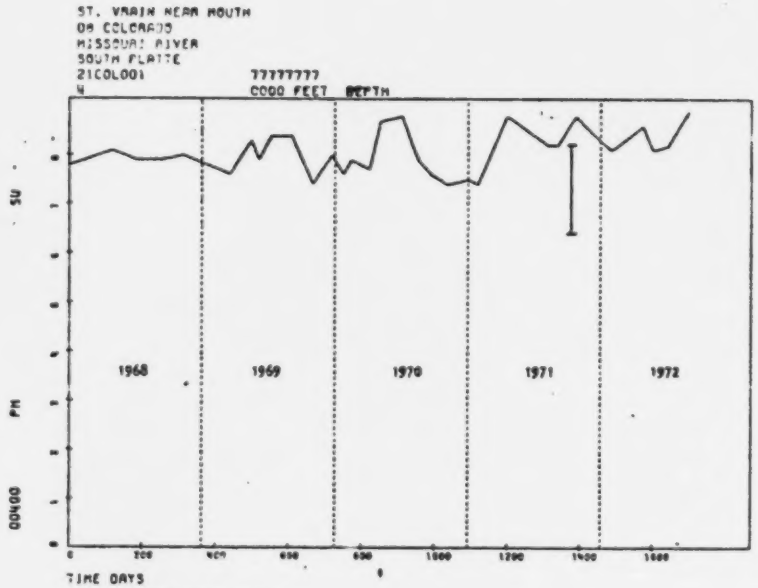

BEAR CREEK AT JEFF ARAP CO LINE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
RK
525.3/1.
1968
1969
1970
1971
1972
TIME DAYS

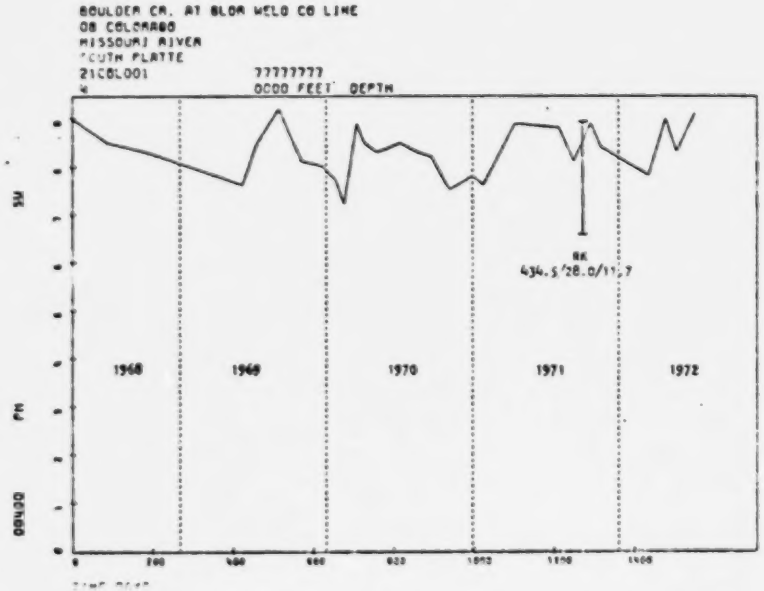

1967
1968
1969
1970
1971
1972

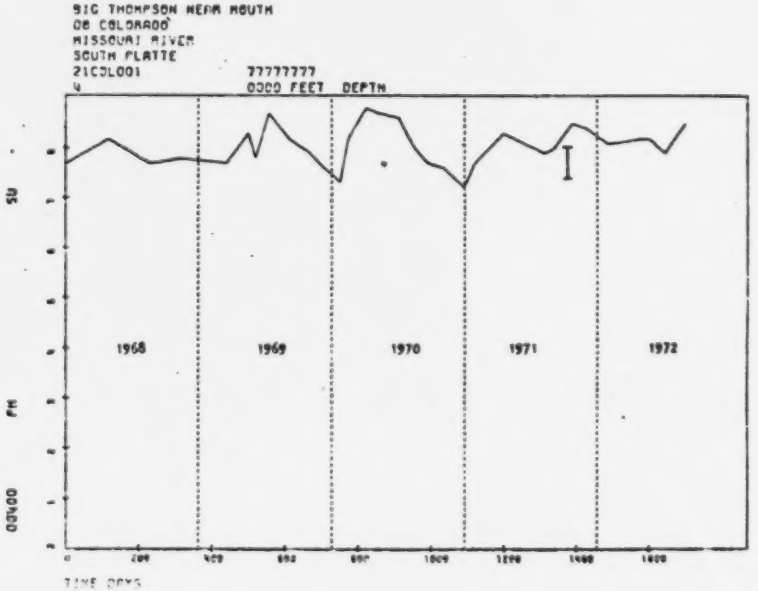

CLEAR CREEK ABOVE GOLDEN
08 COLORADO,
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
RK 500.7/30.
1968
1969
1970
1971
1972

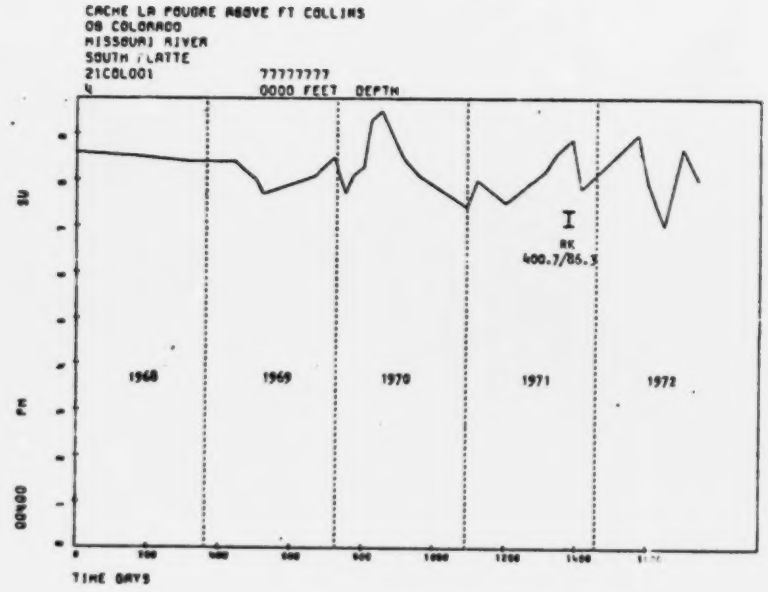

CLEAR CREEK NEAR MOUTH
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972

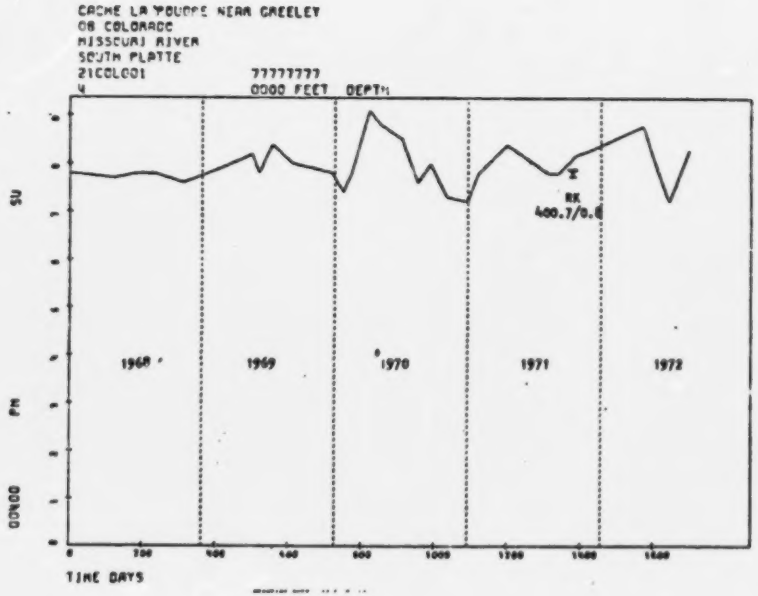

ST VRAIN BELOW LONGMONT
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLOO1 77777777
4 0000 FEET DEPTH
RK
434.5/33.5
1969
1970
1971
1972
TIME DAYS


ST. VRAIN NEAR MOUTH
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLOO1 77777777
4 0000 FEET DEPTH
1968
1969
1970
1971
1972
TIME DAYS


BOULDER CR. AT BLDR WELD CO LINE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLOO1 77777777
4 0000 FEET DEPTH
RK
434.5/28.0/11.7
1968
1969
1970
1971
1972

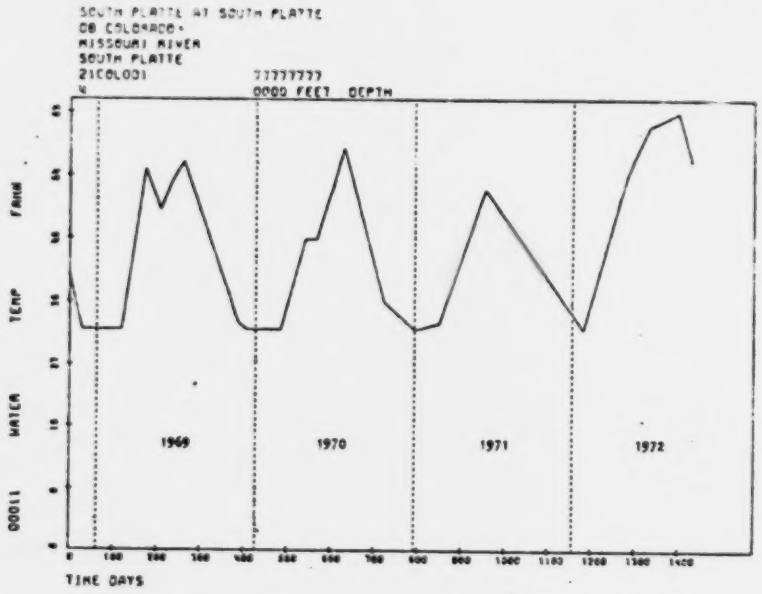

BIG THOMPSON NEAR MOUTH
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLOO1 77777777
4 0000 FEET DEPTH
1968
1969
1970
1971
1972
TIME DAYS

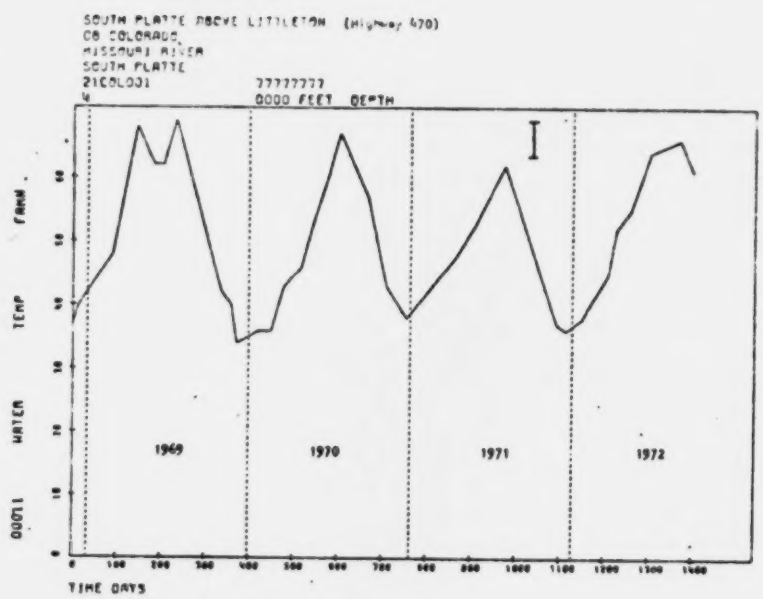

CACHE LA POUDRE ABOVE FT COLLINS
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
SU
FM
0000
1968
1969
1970
1971
1972
RK
400.7/86.3
TIME DAYS

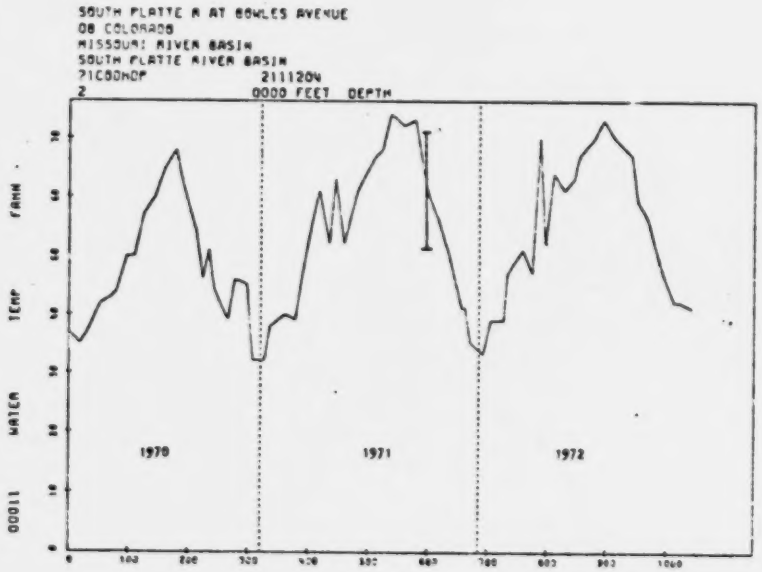

CACHE LA POUDRE NEAR GREELEY
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
SU
FM
0000
1968
1969
1970
1971
1972
RK
400.7/0.0
TIME DAYS

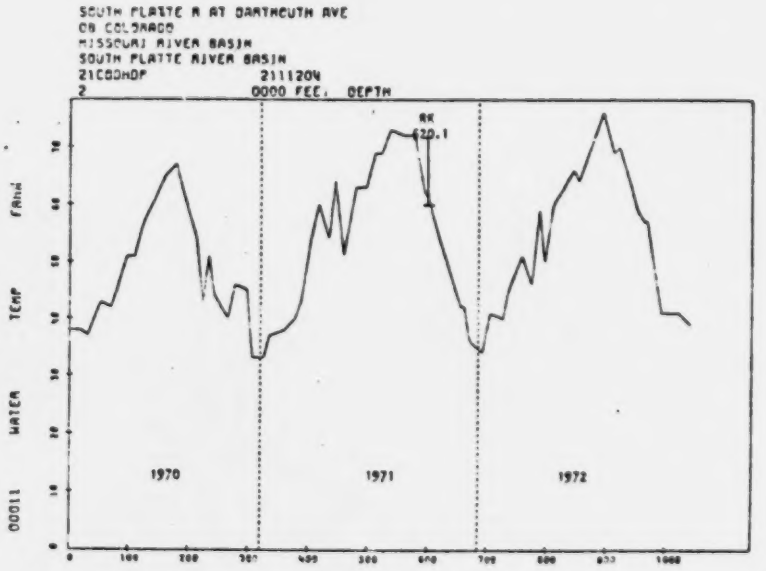
APPENDIX A - 6

Computer Plots of Temperature vs. Time at Long Term Water Quality Monitoring Stations in the South Platte River Basin

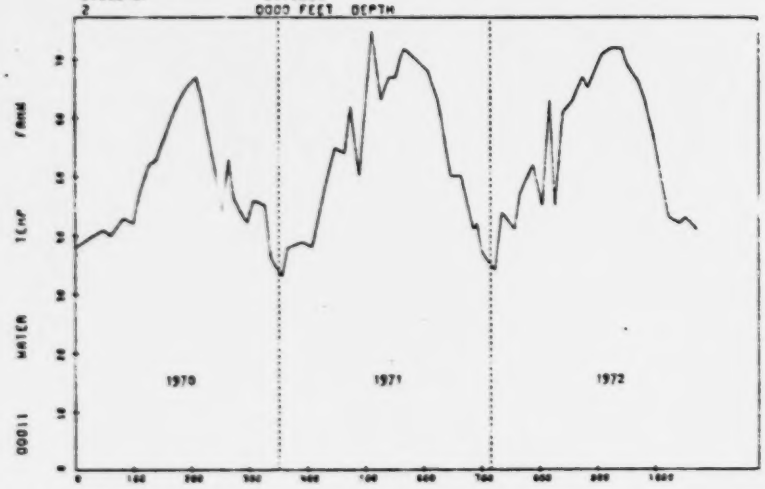

SOUTH PLATTE AT SOUTH PLATTE
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO31 77777777
4 0000 FEET DEPTH
1969
1970
1971
1972
TIME DAYS


SOUTH PLATTE ABOVE LITTLETON (Highway 470)
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO31 77777777
4 0000 FEET DEPTH
1969
1970
1971
1972
TIME DAYS


SOUTH PLATTE R AT BOWLES AVENUE
CO COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21COOHOP 2111204
2 0000 FEET DEPTH
1970
1971
1972

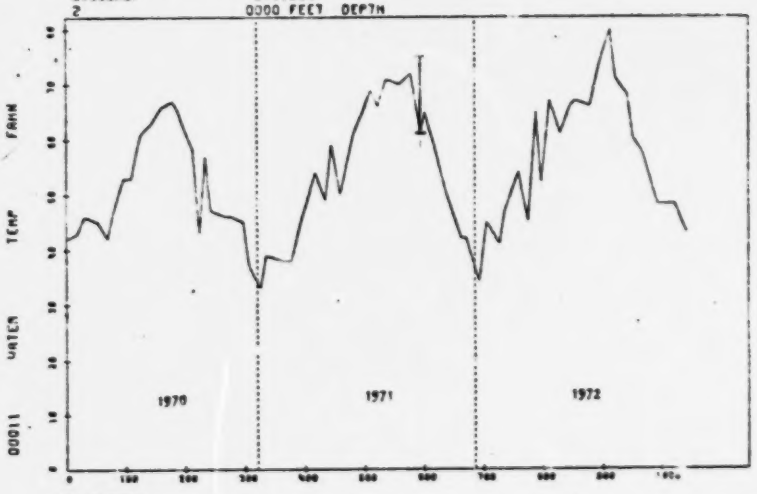

SOUTH PLATTE R AT DARTMOUTH AVE
CO COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21COOHOP 2111204
2 0000 FEET DEPTH
1970
1971
1972

SOUTH PLATTE R AT ALAMEDA AVENUE
OF COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HOP 2111204
2 0000 FEET DEPTH



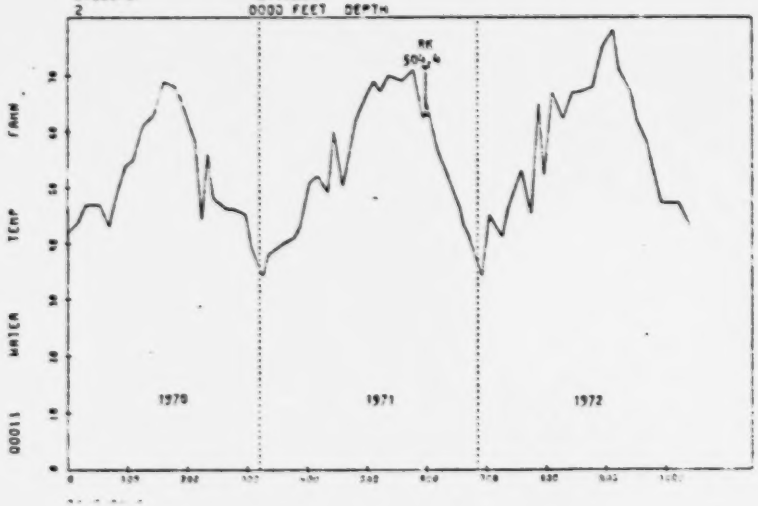
TIME DAYS

SOUTH PLATTE R @ 19TH ST BRIDGE
00 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HOP 2111204
2 0000 FEET DEPTH

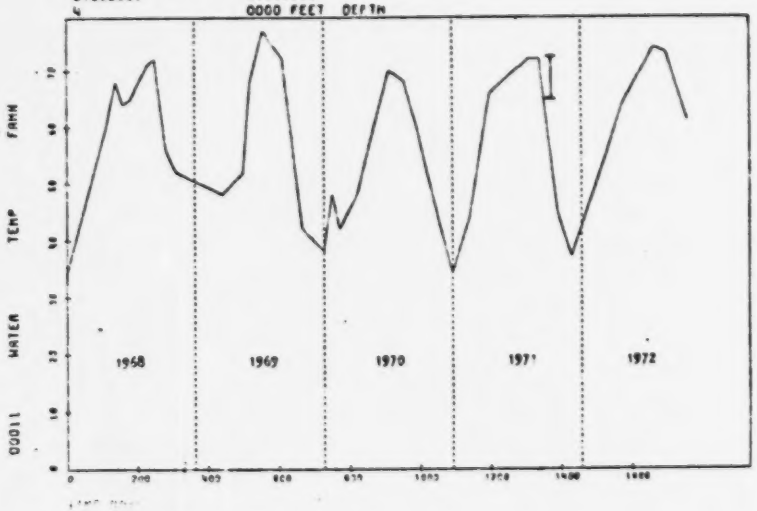


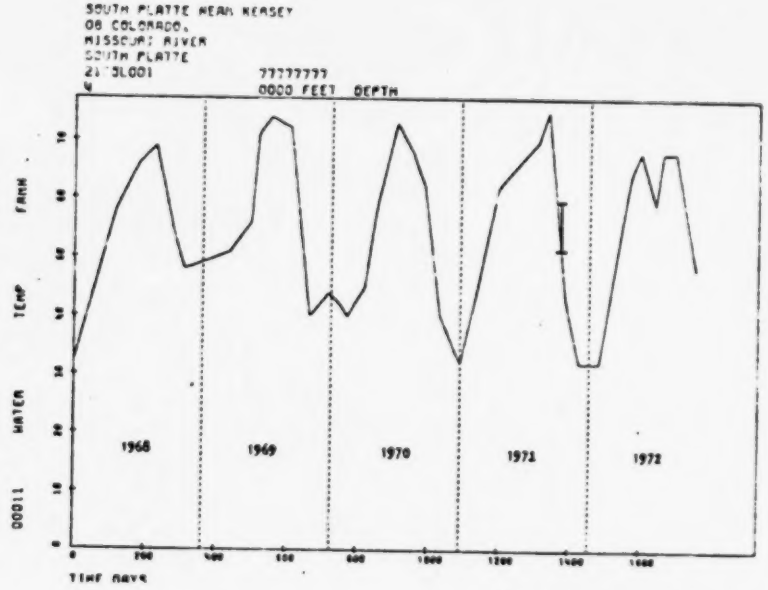
TIME DAYS

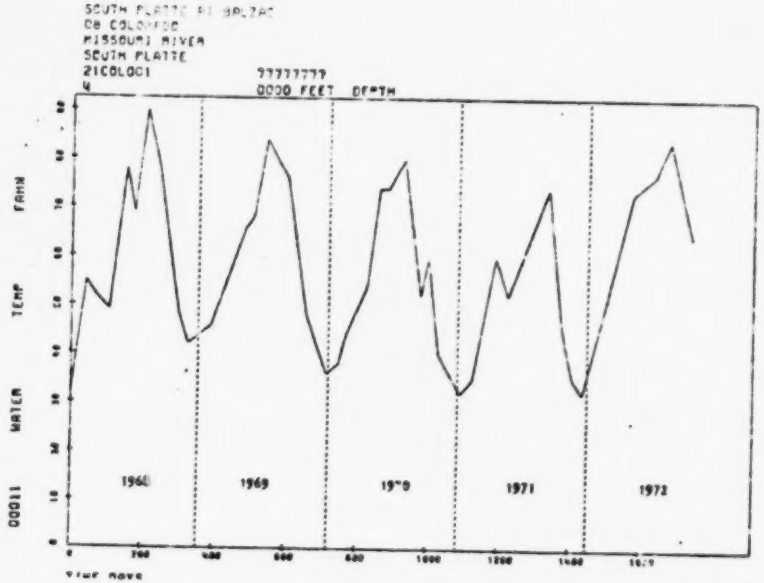
SO PLATTE R @ FRANKLIN ST BRIDGE
00 COLORADO
MISSOURI RIVER BASIN
SOUTH PLATTE RIVER BASIN
21C00HOP 2111204
2 0000 FEET DEPTH

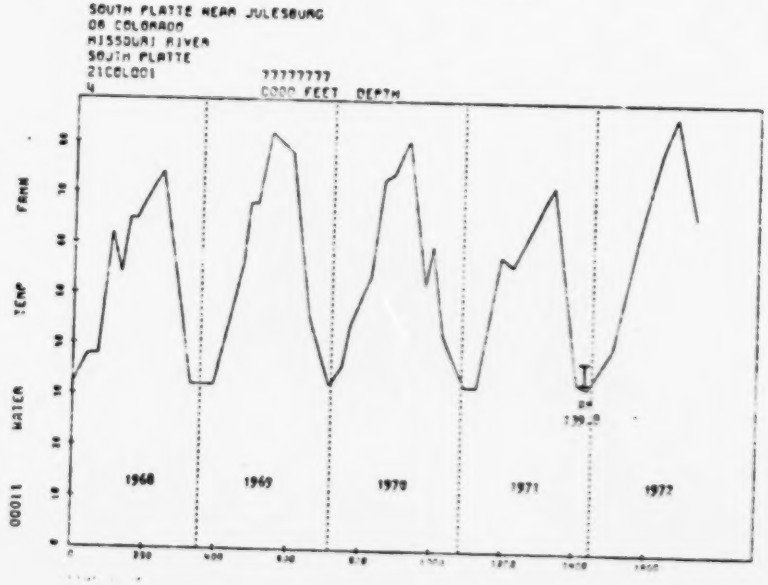


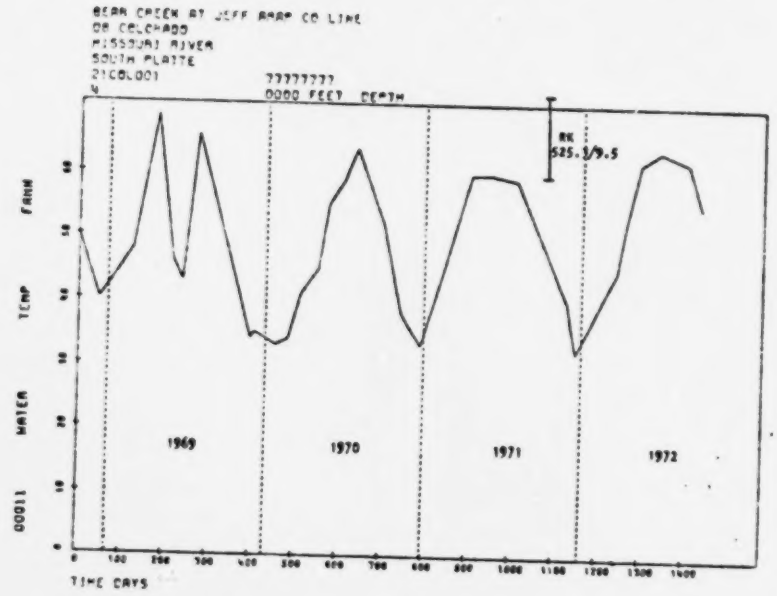
SOUTH PLATTE AT HENDERSON
OF COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001 77777777
4 0000 FEET DEPTH

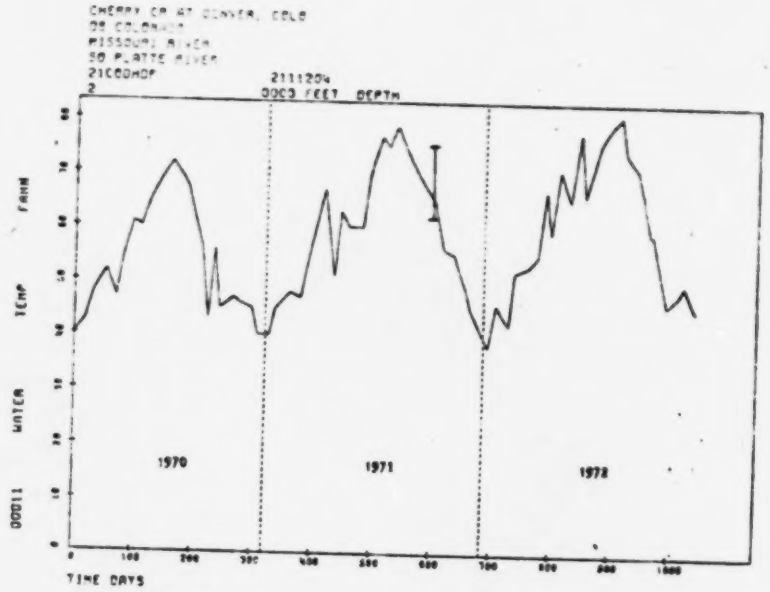


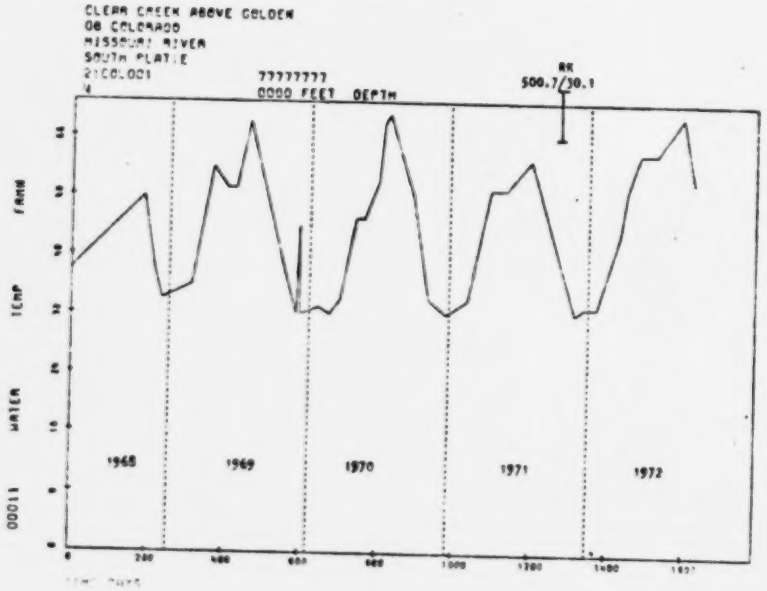

SOUTH PLATTE NEAR KERSEY
OB COLORADO,
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
00011 WATER TEMP FAHN
1968
1969
1970
1971
1972
TIME DAYS

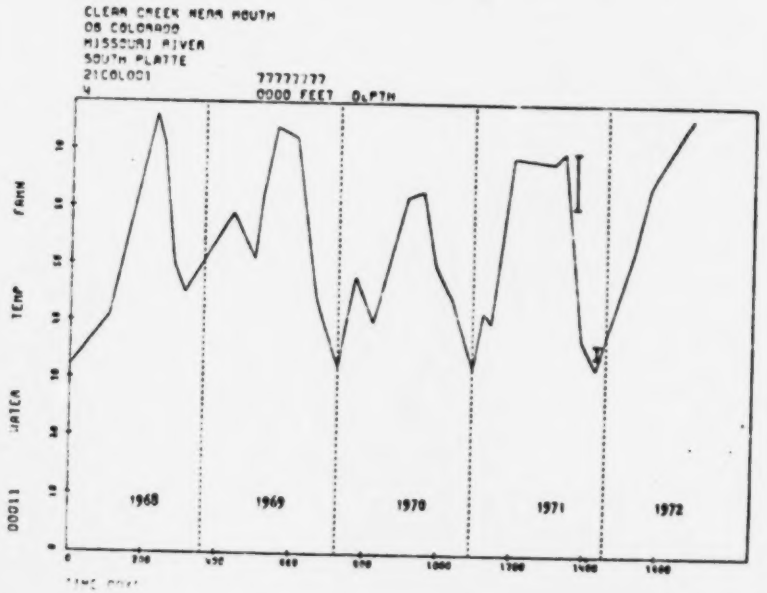

OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
00011 WATER TEMP FAHN
1968
1969
1970
1971
1972
TIME DAYS

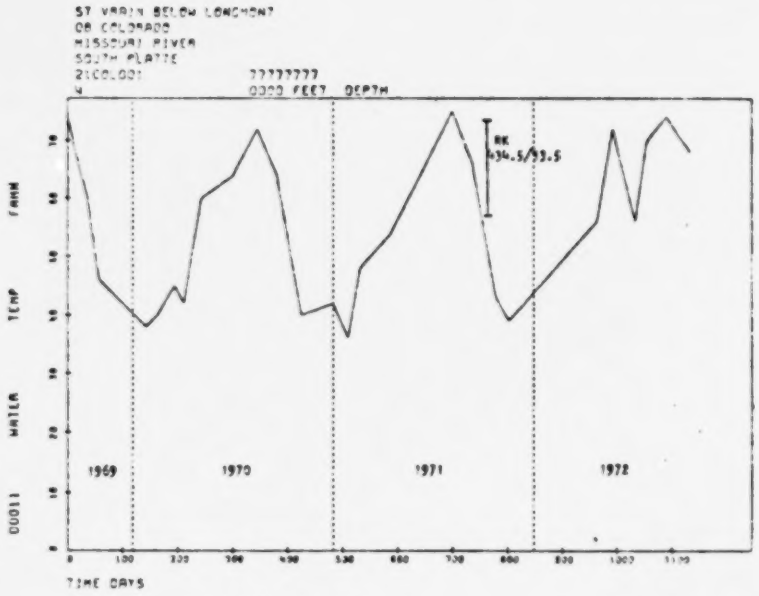

SOUTH PLATTE NEAR JULESBURG
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
00011 WATER TEMP FAHN
1968
1969
1970
1971
1972

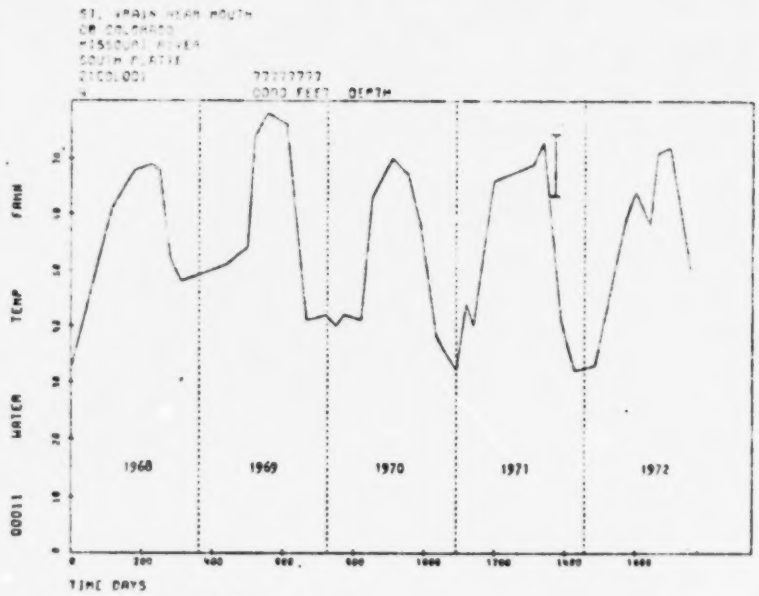

BEAR CREEK AT JEFF BARR CO LINE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
4
77777777
0000 FEET DEPTH
RK
525.1/9.5
00011 WATER TEMP FARH
1969
1970
1971
1972
TIME DAYS

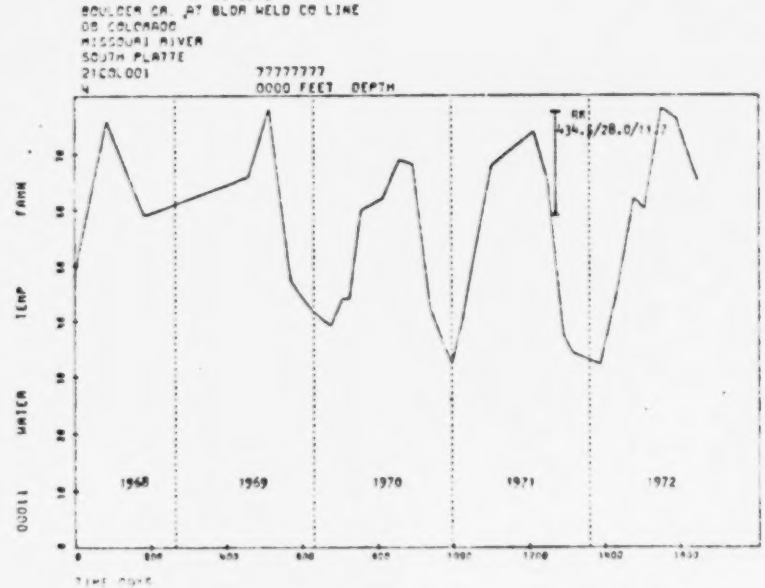

CHERRY CR AT DENVER, COLO
08 COLORADO
MISSOURI RIVER
SO PLATTE RIVER
21COOHOF
2
2111204
0003 FEET DEPTH
00011 WATER TEMP FARH
1970
1971
1972
TIME DAYS

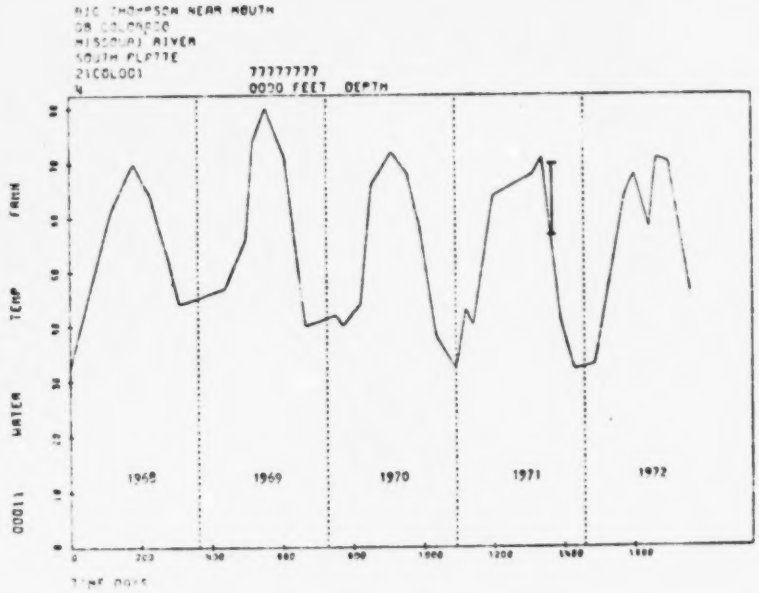

CLEAR CREEK ABOVE GOLDEN
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
4
77777777
0000 FEET DEPTH
RK
500.7/30.1
00011 WATER TEMP FARH
1968
1969
1970
1971
1972

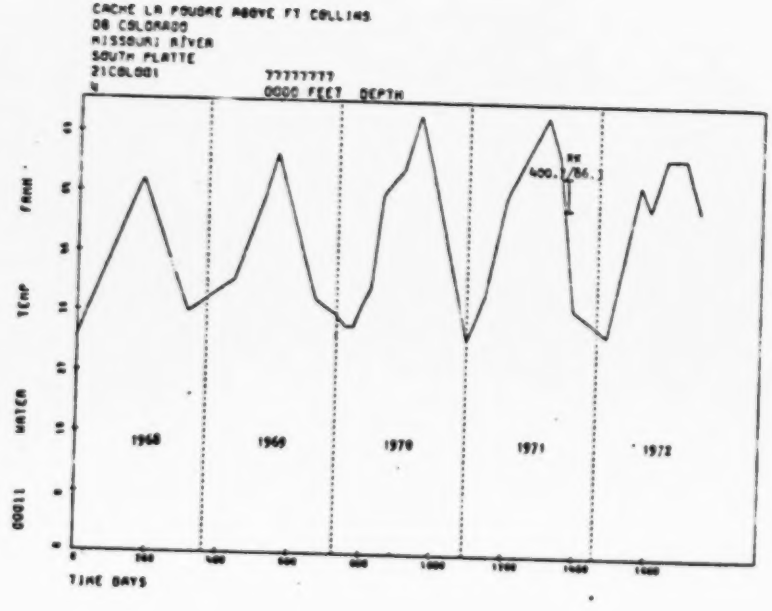

CLEAR CREEK NEAR MOUTH
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
4
77777777
0000 FEET DEPTH
00011 WATER TEMP FARH
1968
1969
1970
1971
1972

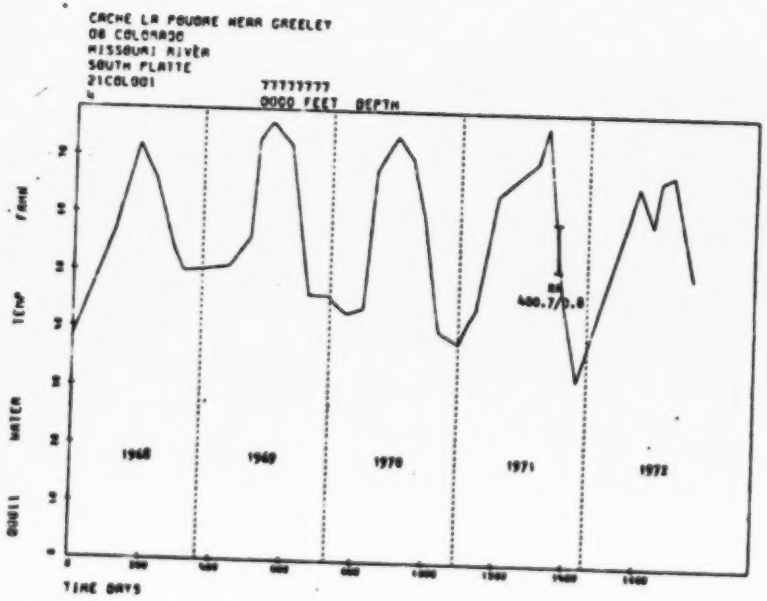

ST VRAIN BELOW LONGMONT
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
RK
434.5/93.5
1969
1970
1971
1972
TIME DAYS


ST. VRAIN NEAR MOUTH
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972
TIME DAYS


BOULDER CR. AT BLDR WELD CO LINE
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972

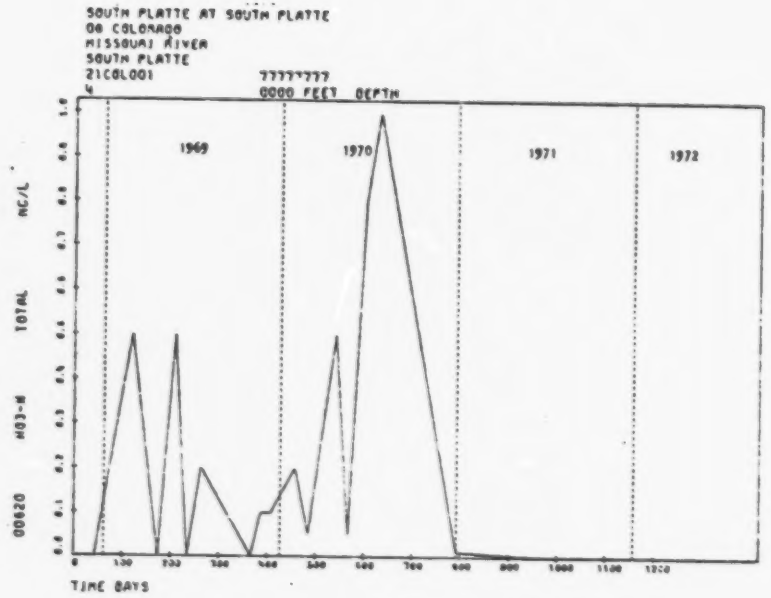

BIG THOMPSON NEAR MOUTH
OR COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1968
1969
1970
1971
1972

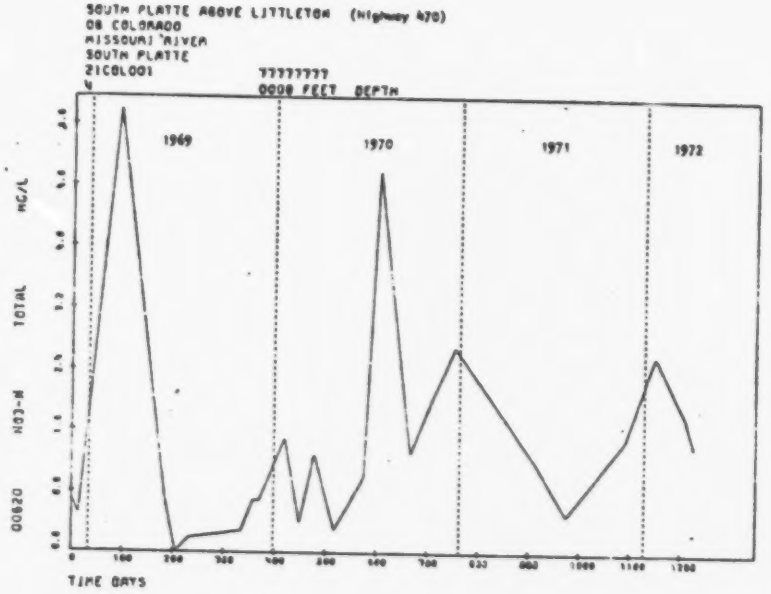

CACHE LA POUDRE ABOVE FT COLLINS
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
400.1/86.1
1968
1969
1970
1971
1972
TIME DAYS

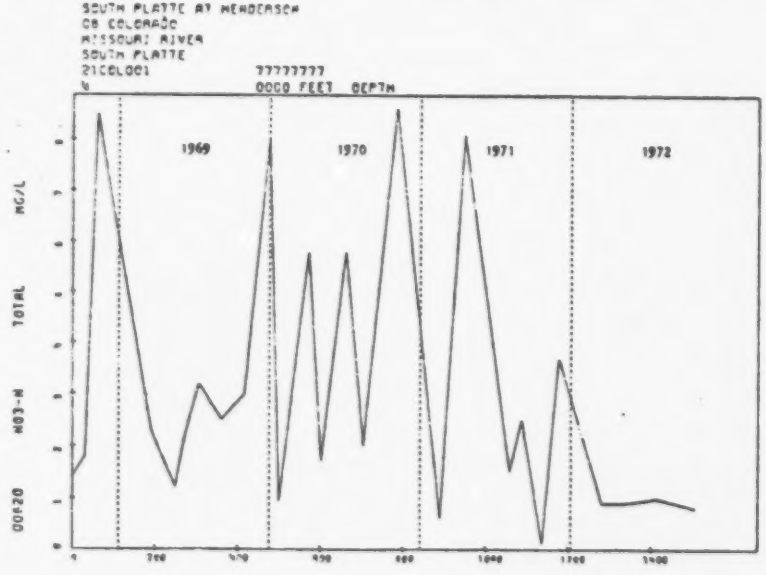

CACHE LA POUDRE NEAR GREELEY
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
400.7/0.0
1968
1969
1970
1971
1972
TIME DAYS

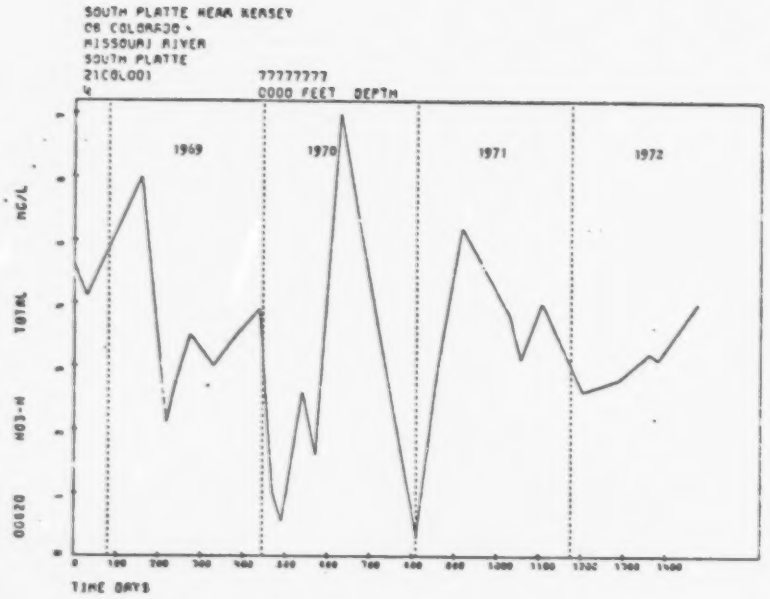
APPENDIX A - 7

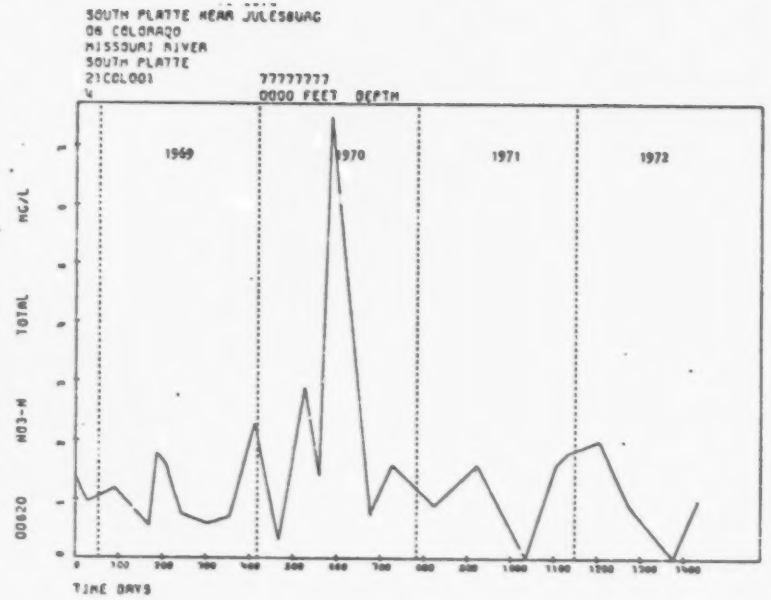
Computer Plots of Nutrient Concentrations vs. Time at Long Term Water Quality Monitoring Stations in the Main Stem South Platte River

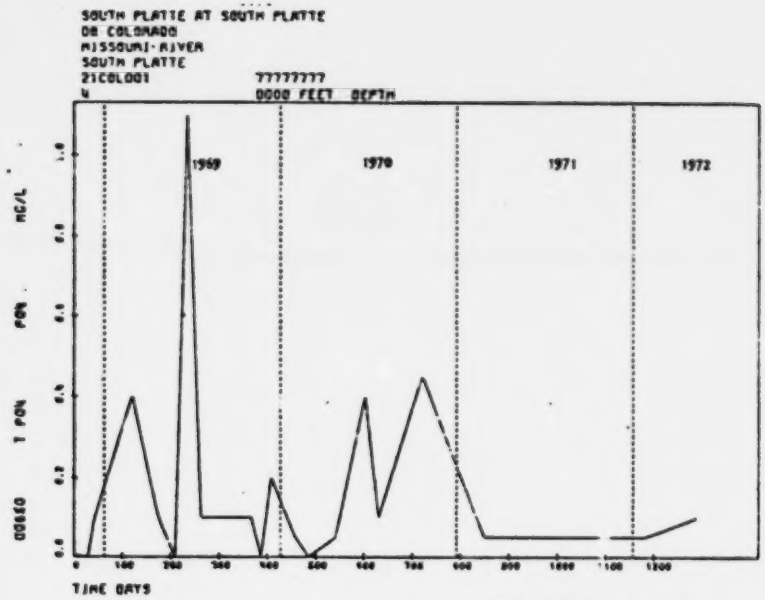

SOUTH PLATTE AT SOUTH PLATTE
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00620 NO3-N TOTAL MG/L
TIME DAYS

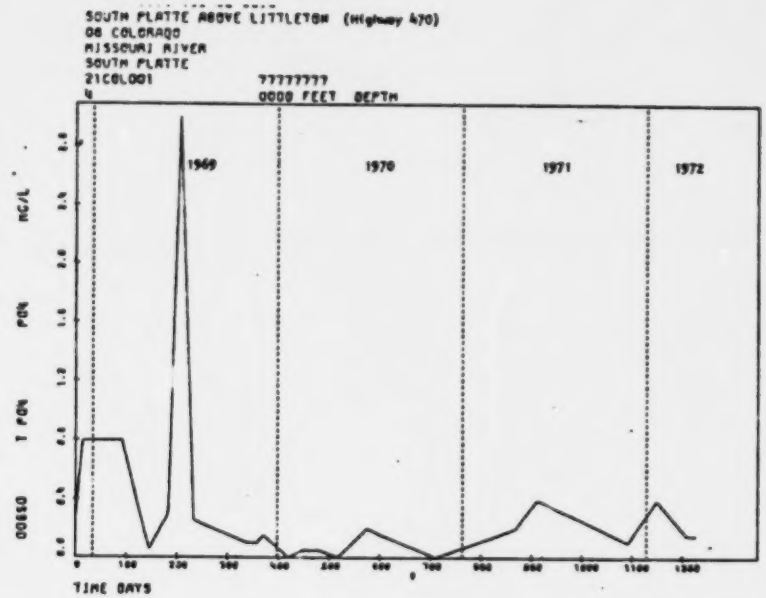

SOUTH PLATTE ABOVE LITTLETON (Highway 470)
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00620 NO3-N TOTAL MG/L
TIME DAYS

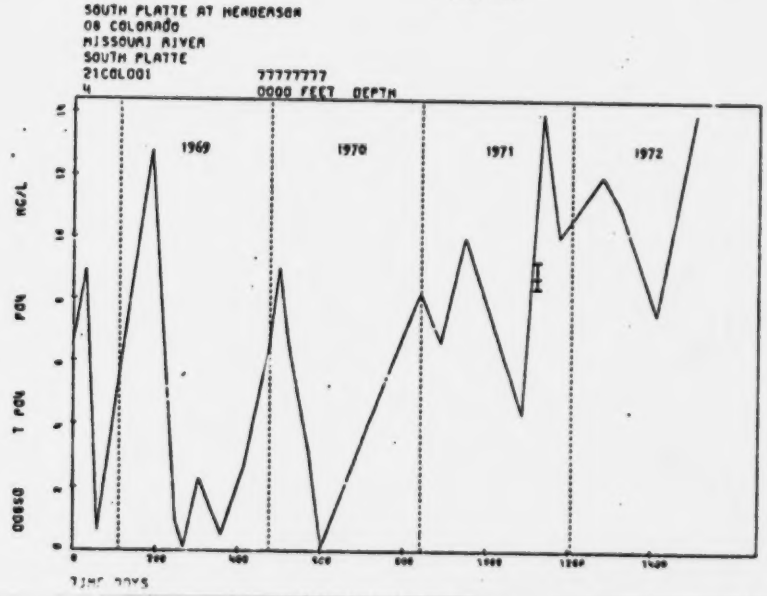

SOUTH PLATTE AT HENDERSON
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00620 NO3-N TOTAL MG/L

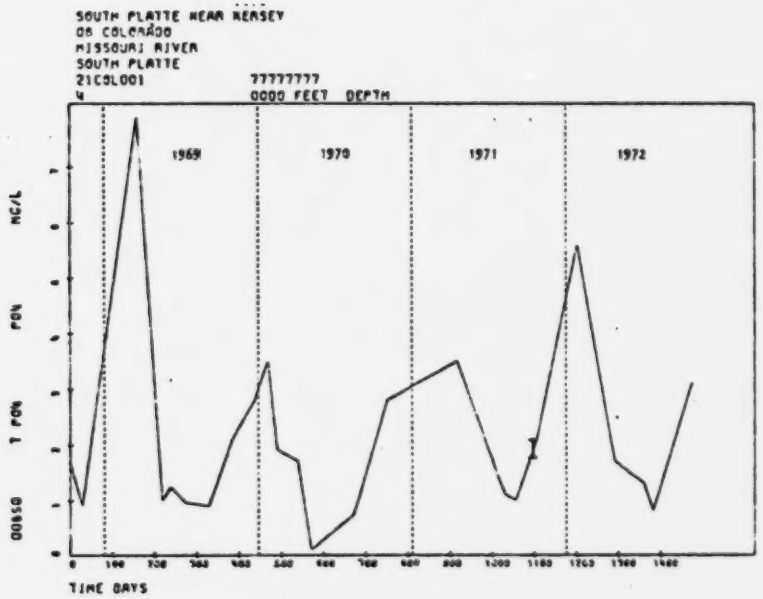

SOUTH PLATTE NEAR KERSEY
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00620 NO3-N TOTAL MG/L
TIME DAYS

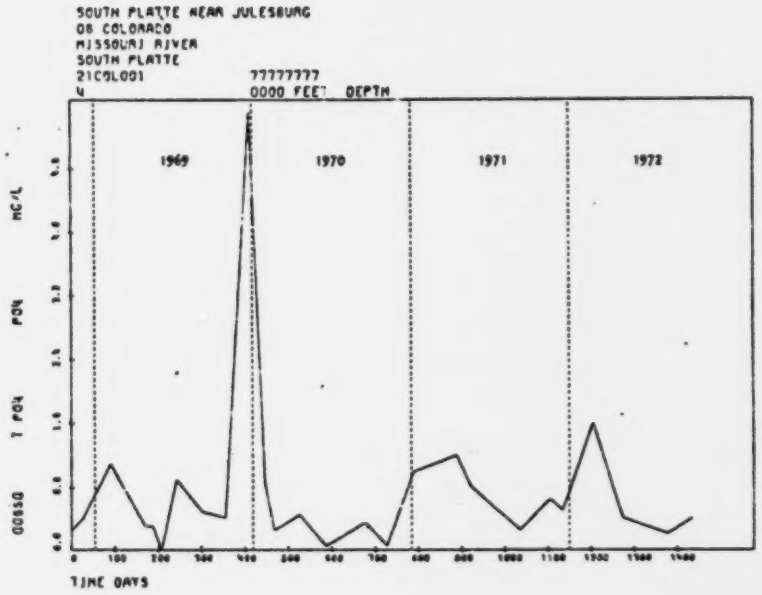

SOUTH PLATTE NEAR JULESBURG
CO COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00620 NO3-N TOTAL MG/L
TIME DAYS

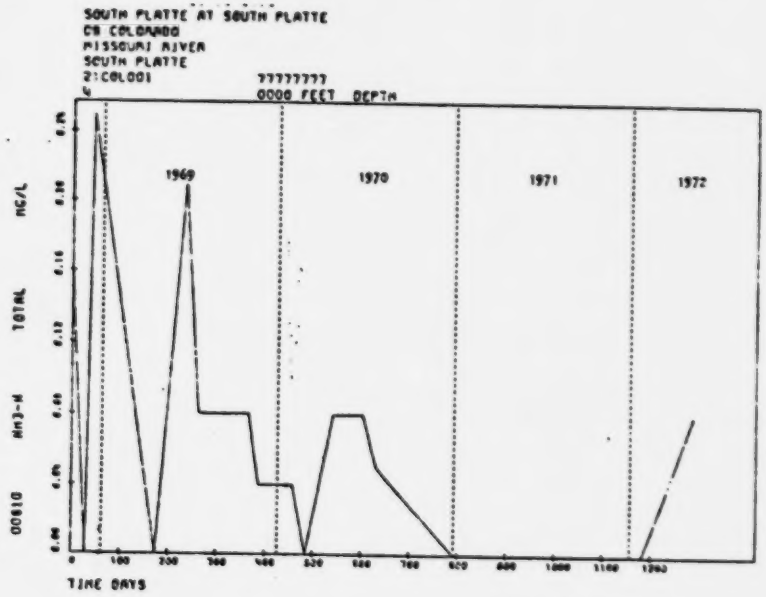

SOUTH PLATTE AT SOUTH PLATTE
08 COLORADO
MISSOURI-RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00630 T KJN KJN MG/L
TIME DAYS

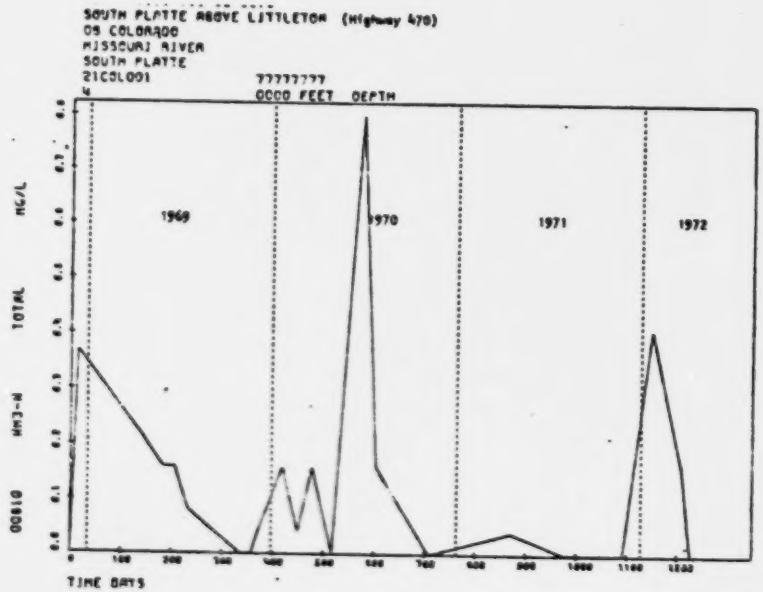

SOUTH PLATTE ABOVE LITTLETON (Highway 470)
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00630 T KJN KJN MG/L
TIME DAYS

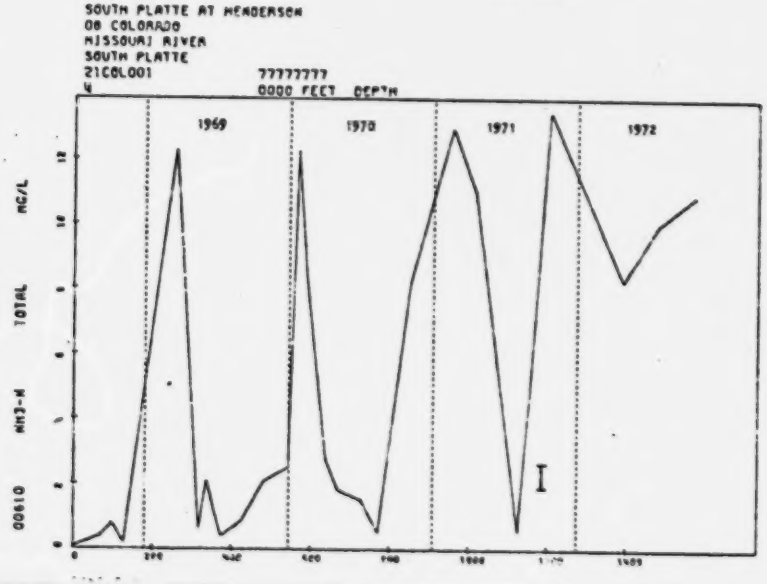

SOUTH PLATTE AT HENDERSON
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00630 T KJN KJN MG/L
TIME DAYS

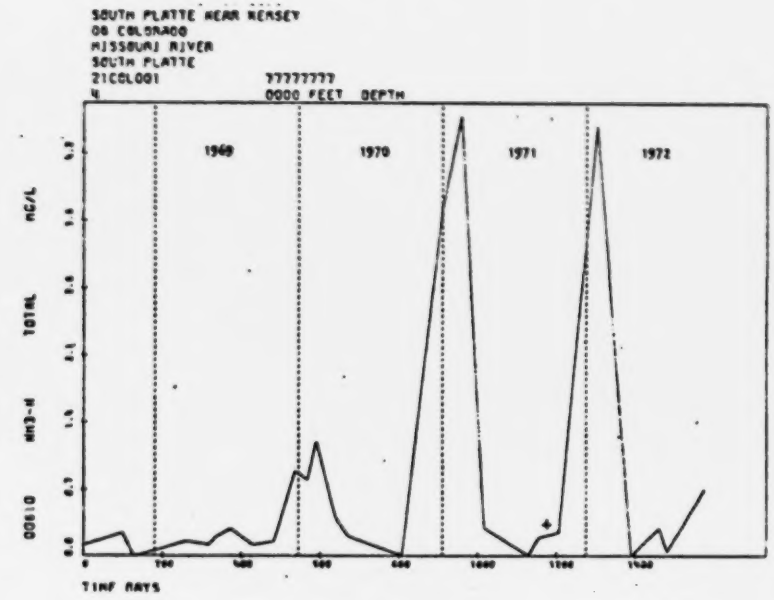

SOUTH PLATTE NEAR KERSEY
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21C9L001
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00630 T PON MG/L
TIME DAYS

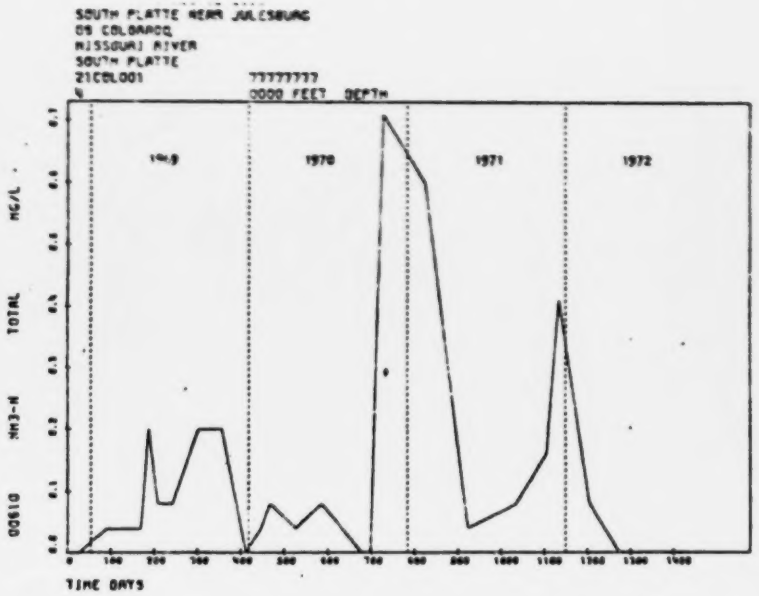

SOUTH PLATTE NEAR JULESBURG
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21C9L001
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00630 T PON MG/L
TIME DAYS

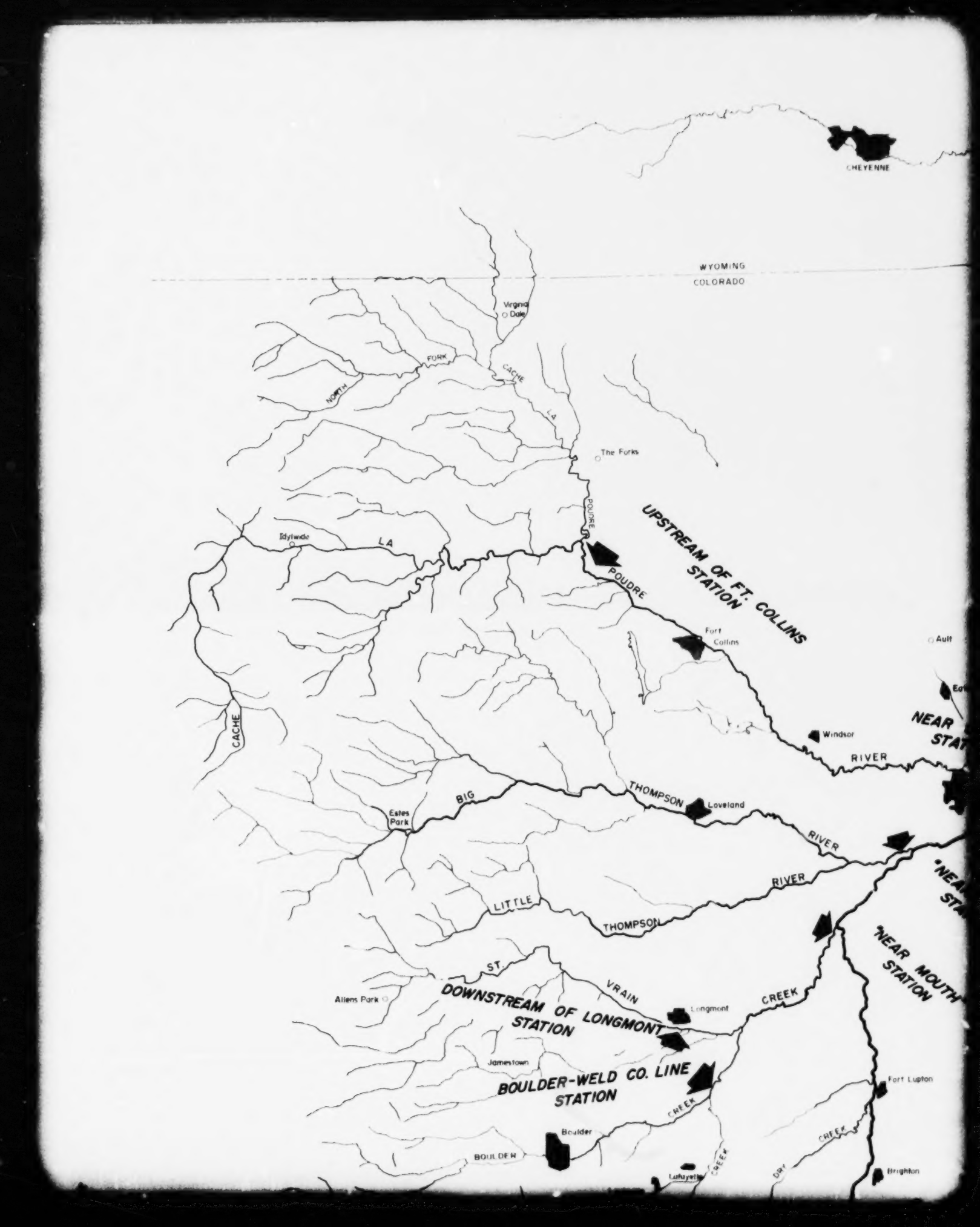

SOUTH PLATTE AT SOUTH PLATTE
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00610 NH3-N TOTAL MG/L
TIME DAYS

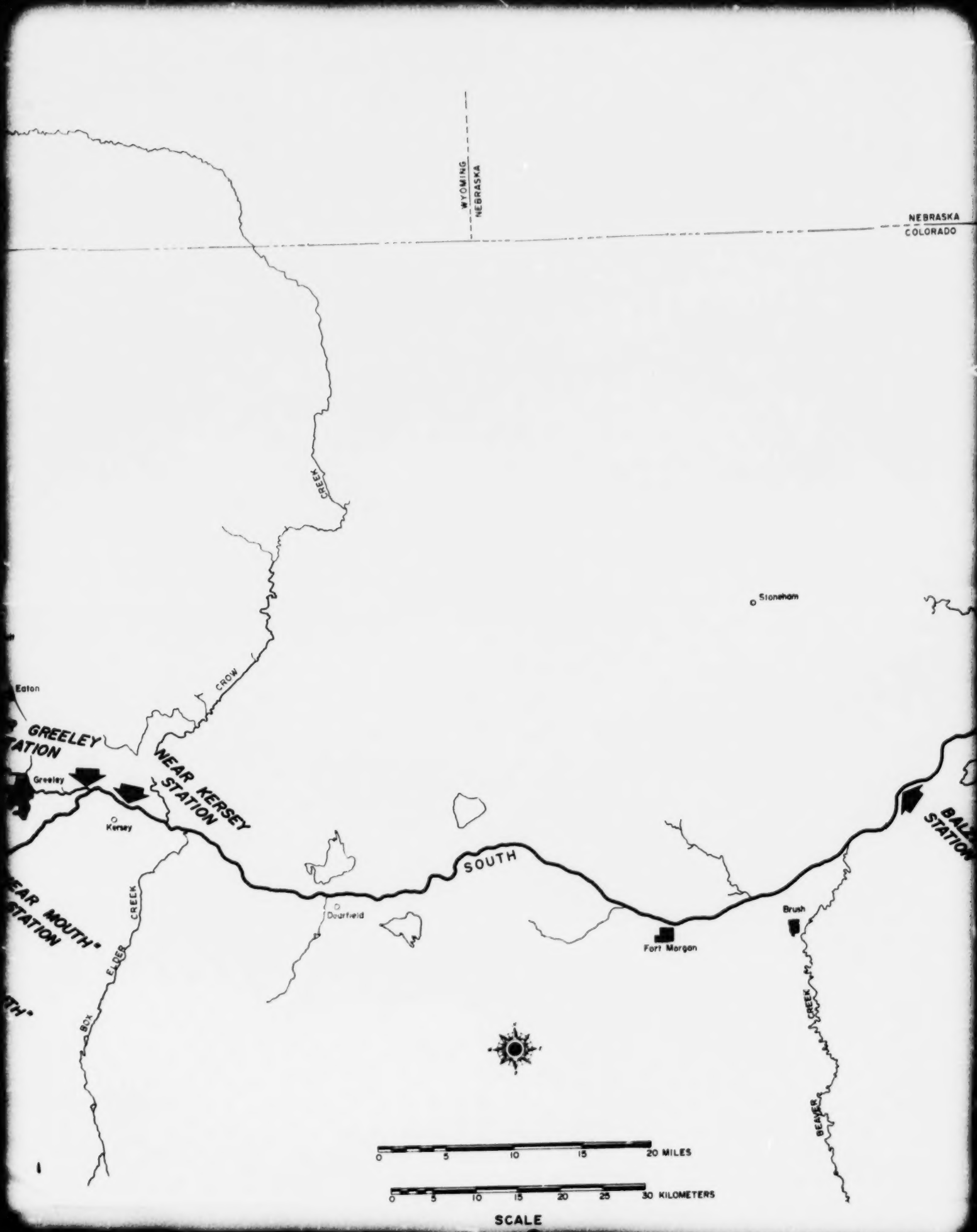

SOUTH PLATTE ABOVE LITTLETON (Highway 470)
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00610 NH3-N TOTAL MG/L
TIME DAYS

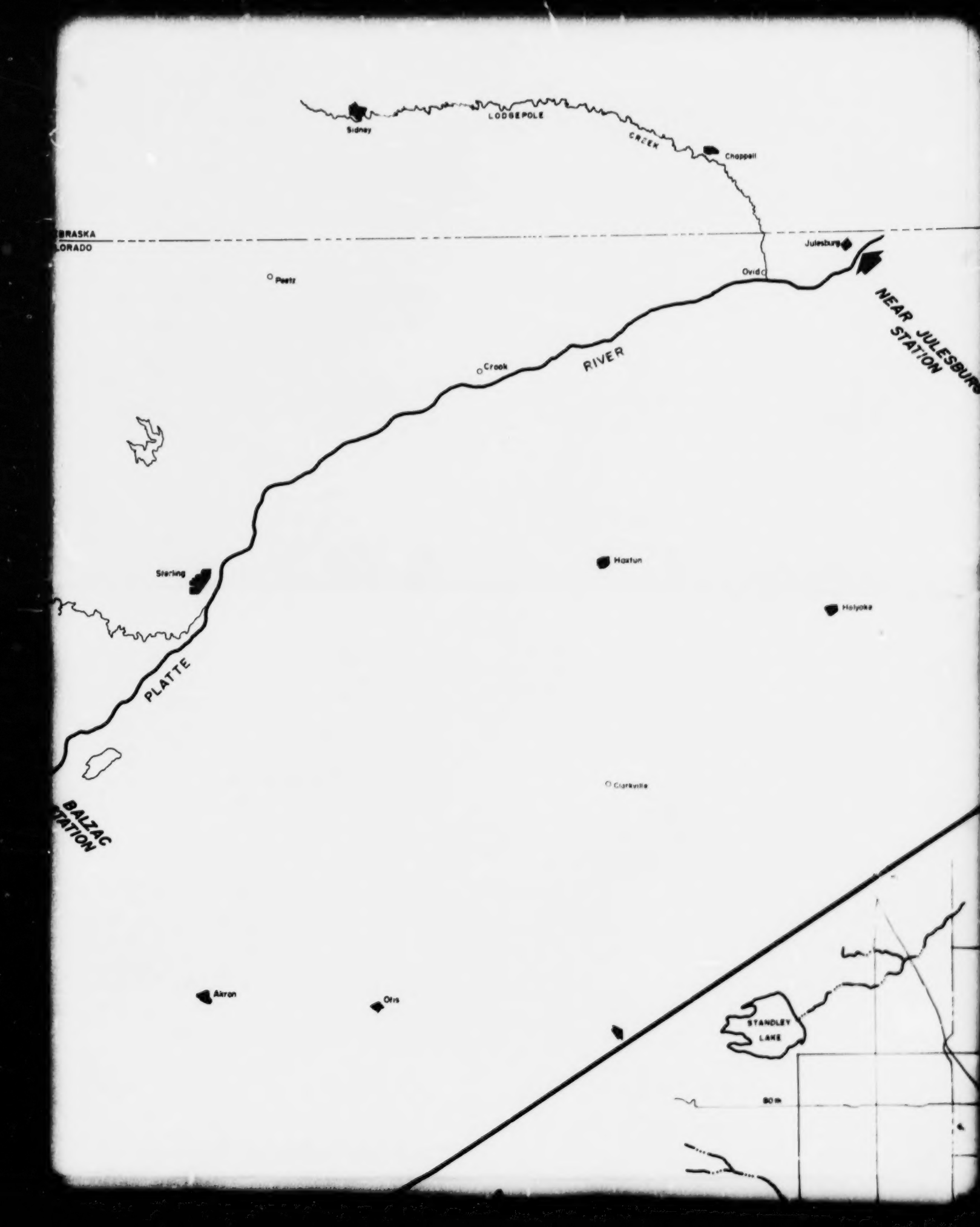

SOUTH PLATTE AT HENDERSON
08 COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COL001
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00610 NH3-N TOTAL MG/L


SOUTH PLATTE NEAR KERSEY
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
1969
1970
1971
1972
00610 NH3-N TOTAL MG/L
TIME DAYS


SOUTH PLATTE NEAR JULESBURG
OB COLORADO
MISSOURI RIVER
SOUTH PLATTE
21COLO01
4
77777777
0000 FEET DEPTH
1970
1971
1972
00610 NH3-N TOTAL MG/L
TIME DAYS


CHEYENNE
WYOMING
COLORADO
Virginia Dale
NORTH FORK
CACHE LA
The Forks
POUDRE
Idylwide
LA
POUDRE
UPSTREAM OF FT. COLLINS STATION
Fort Collins
Ault
CACHE
Windsor
RIVER
NEAR STAT
BIG
THOMPSON
Loveland
Estes Park
RIVER
RIVER
LITTLE
THOMPSON
NEAR MOUTH STATION
ST.
VRAIN
CREEK
Allens Park
DOWNSTREAM OF LONGMONT STATION
Longmont
Jamestown
BOULDER-WELD CO. LINE STATION
Fort Lupton
CREEK
Boulder
BOULDER
CREEK
Lafayette
DRY
CREEK
Brighton


WYOMING
NEBRASKA
NEBRASKA
COLORADO
CREEK
Stoneham
Eaton
CROW
GREELEY
STATION
Greeley
WEAR KERSEY
STATION
Kersey
SOUTH
Deerfield
Fort Morgan
Brush
BOX ELDER CREEK
BEAVER CREEK
0 5 10 15 20 MILES
0 5 10 15 20 25 30 KILOMETERS
SCALE


LODGEPOLE
CREEK
Sidney
Chappell
BRASKA
LORADO
Julesburg
Ovid
Peetz
NEAR JULESBURG
STATION
Crook
RIVER
Sterling
Haxtun
Holyoke
PLATTE
Clarkville
BALZAC
TATION
Akron
Otis
STANDLEY
LAKE
80 m

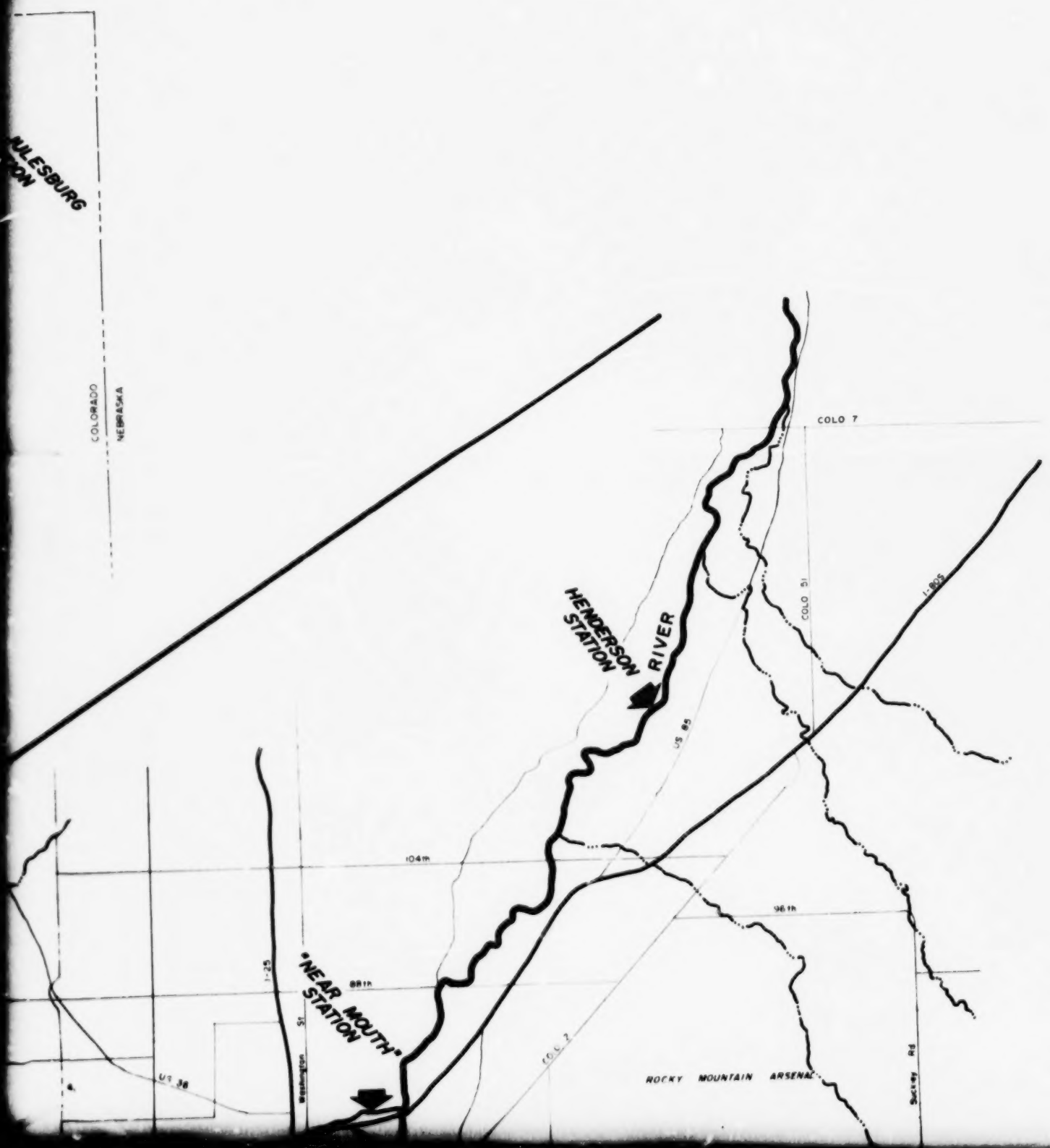
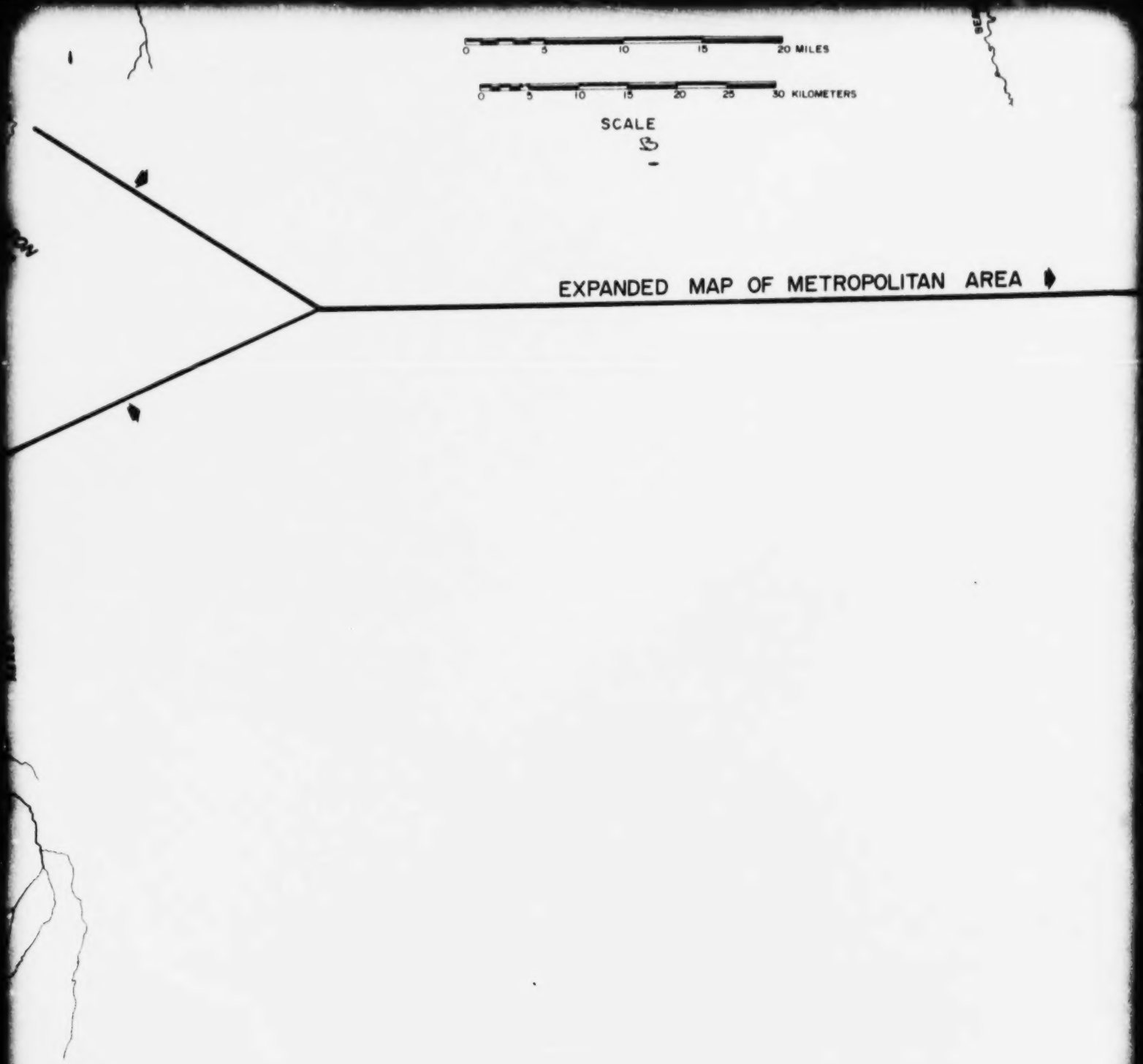

ULESBURG
ON
COLORADO
NEBRASKA
COLO 7
HENDERSON STATION
RIVER
COLO 51
I-805
US 85
104th
98th
88th
I-25
NEAR MOUTH
STATION
COLO 2
ROCKY MOUNTAIN ARSENAL
Sucksy Rd
US 36

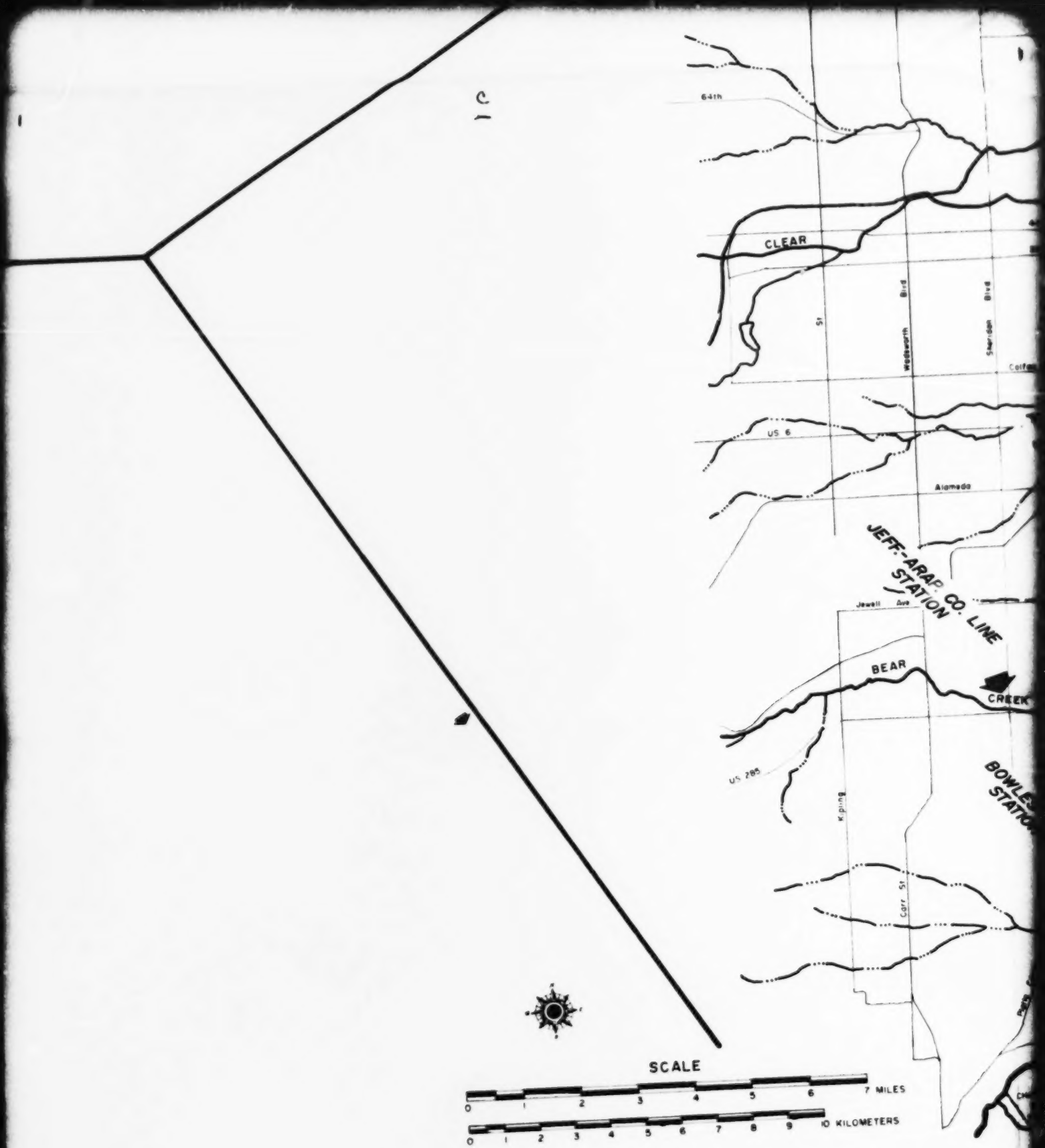
Figure 1 left (west) half



IGURE 1

SOUTH PLATTE RIVER SYSTEM SHOWING SELECTED WATER QUALITY SURVEILLANCE STATIONS IN COLORADO

RADO
RINGS


64th
CLEAR
Wadsworth Blvd
Sheridan Blvd
US 6
Alameda
JEFF.-ARAP. CO. LINE
STATION
Jewell Ave
BEAR
CREEK
US 285
Carr St
SCALE
0 1 2 3 4 5 6 7 MILES
0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

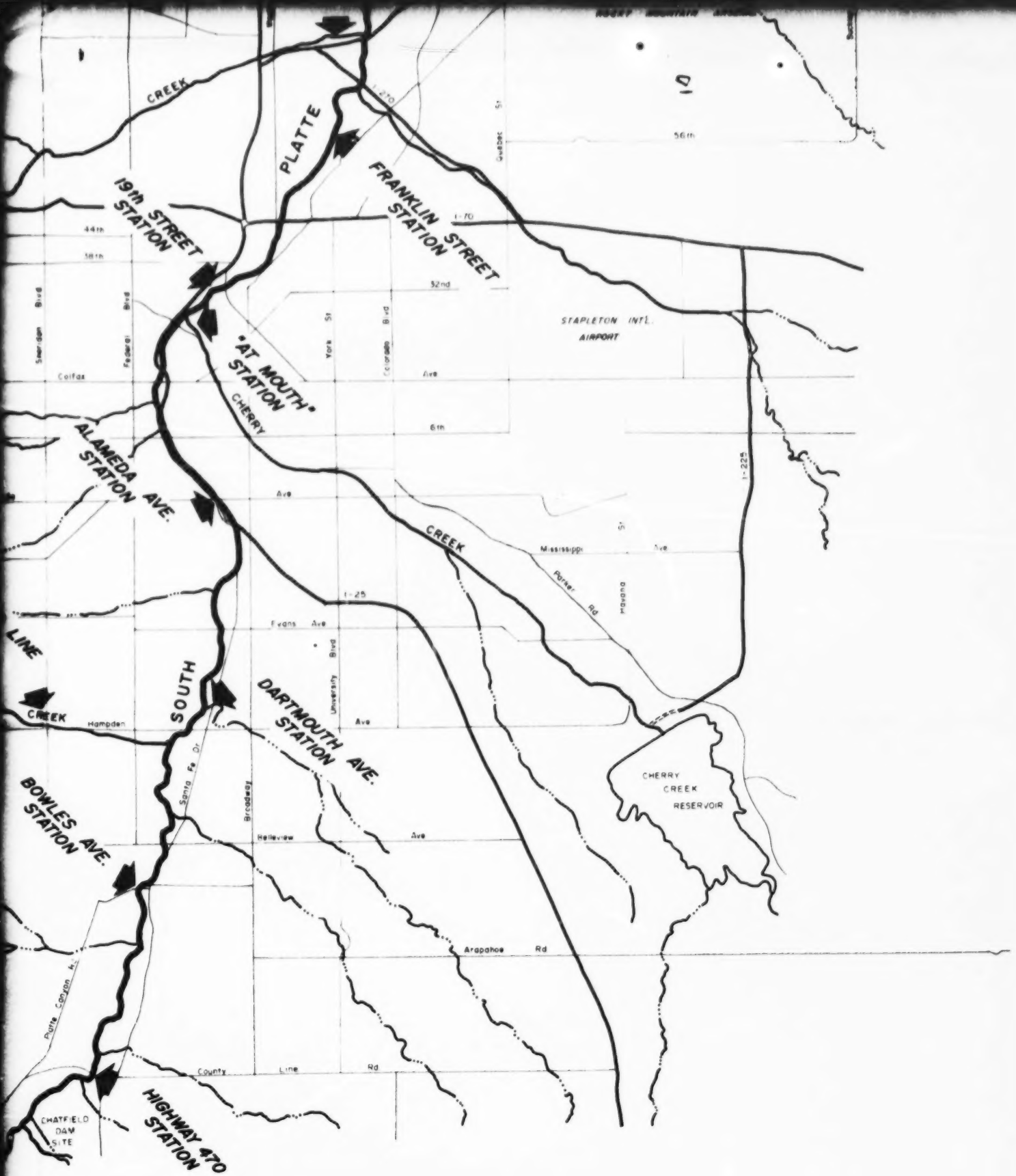


Figure 1 right (east) half